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P30823

CONTENTS

		Page
Direct and residual effect of levels of zinc and iron and their mode of application on productivity of rice-wheat cropping system	*S. Kulandaivel, B.N. Mishra and P.K. Mishra*	221
Heterosis and combining ability for some quality traits in rice (*Oryza sativa L.*)	*CH.S. Raju, M.V.B. Rao, G.L.K. Reddy, J.S.P. Rao and K.S. Reddy*	227
Evaluation of mango genotypes for their flowering, fruiting and fruit quality attributes	*Sanjay Singh*	234
Impact of paper mill effluent and distillery effluent irrigation on yield and nutrient uptake of rice	*Anish Chatterjee, H.C. Joshi and Mahua Banerjee*	239
Inheritance of resistance to black rot disease in late cauliflower	*B.S. Thakur, B.N. Korla and K. Khosla*	244
Gene action and combining ability in relation to development of hybrids in wheat	*S.K. Singh and R.M. Singh*	249
Genetic divergence studies in salinity tolerant wheat germplasm using cluster analysis	*Indra Singh and D.K. Garg*	256
Genetic variability and correlation studies in ginger *(Zingiber officinale* Rosc.)	*S.K. Tiwari*	261
Characterization of thermal time requirement of five wheat cultivars under varied weather conditions	*N.K. Paikaray and N.V.K. Chakravarty*	266
Economics of plant growth regulators in brinjal	*S.S. Meena and R.S. Dhaka*	273

(*Solanum melogena* L.) under semi-arid condition of Rajasthan

Quality assessment of different arid zone pomegranate cultivars — *Dheeraj Singh and K.K. Meena* 276

Characterization of low temperature protection practices for tomato — *S.K. Dey and S.S Hundal* 283

Physiological studies on pod and seed characters in relation to productivity in garden pea — *Moushumi Sarkar, R.R. Sharma and P.S. Deshmukh* 289

Studies on the minimum isolation requirements for hybrid seed production in chilli (*Capsicum annuum* L.) — *Ruma Devi, S.K. Arora and J.S. Kanwar* 294

Total productivity, sustainability and recovery of P and S by groundnut-sunflower intercropping with simultaneous and staggered planting in relation to P and S fertilization — *S.K. Maity and Gajendra Giri* 301

Effect of dose and application methods of different urea based fertilizers on yield of lowland rice — *A.K. Dash, B.K. Mishra, M.K. Jena and D. Jena* 308

Profile distribution of boron forms in relation to soil characteristics in arid soils of western Rajasthan — *D.R. Chaudhary and L.M Shukla* 314

Changes in host enzyme activity due to induction of resistance against downy mildew in cauliflower — *S. Gawande and P. Sharma* 322

Effect of varieties, sowing dates and nitrogen levels on yield, nutrient uptake and quality of durum wheat (*Triticum durum* Desf.) — *S.C. Kulhari, S.L. Sharma and S.R. Kantwa* 332

Evaluation of some cytoplasmic male sterile lines of rice in Konkan region of Maharashtra state — *D.S. Sawant, V.N. Shetye and M.M. Shirdhankar* 337

Genetic diversity studies in muskmelon — *Harshawardhan Chaudhary and Hari Har Ram* 345

Growth and yield of maize (*Zea mays* L.) as influenced by cropping system and moisture conservation practices under rainfed conditions — *R.K. Shivran and K.S. Rana* 350

Seed yield, quality and economics of soybean (*Glycine max* (L) Merrill) as influenced by levels and sources of sulphur	*R.K. Sharma*	354
Phenotypic stability for pod characters in cowpea	*M.M. Pujari, V. Tewari and B.B. Sinha*	358
Effect of nitrogen and phosphorus on the performance of hybrid brinjal (*Solanum melongena* L.)	*V.K. Gupta, B.K. Srivastava and M.P. Singh*	362
Effect of nitrogen and sulphur levels on the oil and protein yield of mustard (*Brassica juncea*)	*Amar Singh and N.L. Meena*	368
Biochemical basis of resistance in pigeonpea to pod fly [*Melanagromyza obtusa* (Mall.)]	*Omkar Singh*	372
Heterosis in rice	*K.B. Agrawal*	375
Estimates of variation and heritability of some quantitative characters in sugarcane	*K.B. Agrawal*	379
Effect of phosphorus, sulphur and bio-fertilizers on productivity and soil fertility of fenugreek (*Trigonella Foenum-Graecum* L.) and their residual effect on pearlmillet (*Penisetum glucum*)	*B.L. Jat, M.S. Shaktawat and T.C. Poonia*	383
Stability analysis for oil yield and quality in soybean (*Glycine max* (L.) merrill)	*Gurdeep Singh, S.K. Dhillon, B.S. Gill and R.K. Raheja*	390
Combining ability studies in late group cauliflower	*B.S. Thakur and B.N. Korla*	396
Influence of time and number of sprays on population of mustard aphid and seed yield of mustard	*D.B. Ahuja and R.K. Kalyan*	401
Available zinc and its relationship with soil zinc fractions in some alluvial soils	*S.K. Singhal*	405
Effect of integrated nitrogen nourishment and growth regulators on yield attributes and grain yield of hybrid rice	*P.K. Mishra, R.S. Rajput R.K. Tripathy and B.S. Joshi*	411
Character association and regression analysis in chickpea (*Cicer arietinum*)	*Brajesh Gupta, G.K. Shrivastava and M.L. Lakhera*	416

Response of sorghum to iron and zinc	*A.L. Mali and L.N. Dashora*	421
Effect of different spacings on growth and yield of cabbage	*K.K. Meena and R. Paliwal*	423
Effect of foliar application of urea, surfactants and ethyl oleate on nutrient content of peach grafts	*M.M. Sharma, R.P. Awasthi and R.R. Sharma*	426
Yield and economics of rice as influenced by integrated nutrient management	*K. Mahavishnan, A. Sambasiva Reddy and K. Bhanu Rekha*	429
Influence of irrigation scheduling on yield, consumptive use of water, water-use efficiency and economics of rabi sunflower (*Helianthus annuus*)	*S.S. Tomar, A.C. Shivran and H.S. Dungarwal*	432
Effect of sulphur and plant growth-regulators on yield and quality parameters of chickpea (*Cicer arietinum* L.)	*Narendra Kumar, S.S. Khangarot and Raj Pal Meena*	434
Relative profitability of potato varieties in Indore district of Madhya Pradesh	*A.M. Rajput, A.R. Verma and Suchin Kumar Jain*	437
Occurrence of sesame pod bug (*Elasmolomus sordidus Fabricius)* on sesame in vellore and Thiruannamalai districts of Tamil Nadu	*S. Kalaiyarasan and S. Palanisamy*	440
Population, biomass and nutrient uptake of weeds in sunflower as influenced by weed management	*V.S. Rathore and R.C. Gautam*	444
Inheritance of dwarf profuse tillering habit in rice (*Oryza sativa* L.)	*S.K. Bera*	447
Productivity potential of pigeonpea (*Cajanus cajan* L. Millsp) genotypes in response to growth regulators under *vertisols* of Chhattisgarh plains	*Tej Lal Kashyap, G.K. Shrivastava R. Lakpale and N.K. Choubey*	449
Genetic variability and association between plant height and base diameter in Capsularis jute	*Nitendra Prakash, B.P. Pandey S.P. Singh and P.K. Singh*	453
Influence of integrated weed management on energetics of soybean	*Deepak Kumar, B.L. Chandrakar, P.K. Mishra and Rishi Kumar Mahobia*	455

Ann. agric. Res. New Series Vol. **24** (2) : 221-226 (2003)

DIRECT AND RESIDUAL EFFECT OF LEVELS OF ZINC AND IRON AND THEIR MODE OF APPLICATION ON PRODUCTIVITY OF RICE-WHEAT CROPPING SYSTEM

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ABSTRACT

Field experiments were conducted during *kharif* and *rabi* seasons of 1999-2000 and 2000-2001 to find out the optimum dose and suitable mode of application of zinc and iron on productivity of hybrid rice and its residual effect on succeeding wheat. Levels of $ZnSO_4$ and $FeSO_4$ spectacularly improved the overall development of the crops over control. Application of 30 kg $ZnSO_4$ and 10 kg $FeSO_4$ ha^{-1} with its incubated mode of application produced the grain yield of rice on par with that of non-incubated mode of 40 kg $ZnSO_4$ and 10 kg $FeSO_4$ ha^{-1}. The residual effect of $FeSO_4$ and $ZnSO_4$ also resulted an appreciable improvement in the grain yield of succeeding wheat. To sustain the exploitative nutrients in rice-wheat cropping system, it is very imperative to apply the essential micronutrients like Zn and Fe which was virtually ignored after the green revolution.

Key words : $FeSO_4$, $ZnSO_4$, rice, wheat, mode of application, yield attributes, yield.

The advent of high yielding short duration semi-dwarf rice and wheat varieties, frequent use of high levels of fertilizers and irrigation has resulted into increased cropping system intensity and crop productivity in India. In the areas of intensive cropping system, application of micronutrients is almost ignored that leads to imbalance in the nutrient management. Under this highly exploitative cropping system, the yield plateau became a typical problem. To overcome this problem, application of nutrients like Zn and Fe at appropriate level through its best mode of application in rice-wheat cropping system became imperative to break the yield barriers to sustain the total production of the system.

MATERIALS AND METHODS

Field experiments were conducted during *kharif* and *rabi* seasons of 1999-2000 and 2000-2001, at the farm of Indian Agricultural Research Institute, New Delhi on a well drained loamy soil containing 0.54 per cent organic carbon, low in available N, medium in available P and high in K. The zinc and iron content in the soil were 1.5 and 14.0 ppm, respectively which were far less than the normal critical requirement. The pH of the soil was 8.1 which was almost unfavourable for the micronutrient availability. The experiment was laid out in a randomized block design with three replications. Application of $ZnSO_4$ @ 10, 20, 30 and 40 kg ha^{-1} and $FeSO_4$ @ 5 and

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10 kg ha^{-1} with a common control for both the micronutrient sources was also included in the study. In the mode of application, $ZnSO_4$ @ 10, 20, 30 and 40 kg ha^{-1} and @ 5 and 10 kg ha^{-1} were incubated as per the treatment with well composed farm yard manure for a period of 40 days before application. Hybrid rice Pro Agro 6207 and wheat HD 2309 were taken as test varieties in the system. All the treatments were applied to rice crop and their residual effect were studied on the succeeding wheat. All recommended agronomic management practices of the crops other than treatments were followed.

RESULTS AND DISCUSSION

Growth attributes of rice

Application of $ZnSO_4$ had positive response on number of tillers m^{-2}, dry matter production, leaf area index and crop growth rate (Table 1). On an average, the maximum dry matter (162.80 q ha^{-1}) at harvest was recorded with the application of 40 kg $ZnSO_4$ ha^{-1}, while it was minimum (142.76 q ha^{-1}) with control. Application of $ZnSO_4$ up to 30 kg ha^{-1} showed positive influence on leaf area index over its lower levels. This profound increase in the growth attributes were due to involvement of Zn in auxin metabolism which led to higher hormonal activity at critical growth stages.

Both the micronutrient sources with their levels and mode of application failed to influence the growth parameters of rice. Sakal *et al.* (1985) also reported the similar views.

Yield attributes and yield of rice

Yield attributes of hybrid rice viz., number of panicles m^{-2}, number and weight of grains $panicle^{-1}$ were appreciably higher due to incubated mode of application of $FeSO_4$ and $ZnSO_4$ over control. Application of 30 kg $ZnSO_4$ ha^{-1} appeared to be most effective. $FeSO_4$ even up to 10 kg ha^{-1}, through either of the mode of application failed to influence the yield attributes of rice (Table 2). The role of Fe in rice is unparallel, but the amount of Fe under irrigated rice paddies are virtually sufficient that might be the reason for the poor response of the levels and mode of Fe application. These observations are in agreement with the findings of Ghosh and Jena (1989). Incubated mode of application of $ZnSO_4$ and $FeSO_4$ appreciably improved the yield attributes viz., number of panicles m^{-2} and number of grains $panicle^{-1}$.

The successive increase in the level of $ZnSO_4$ and $FeSO_4$ resulted a positive response on the grain and straw yields of rice. However, it was significant only upto a level of 30 kg $ZnSO_4$ ha^{-1} (Table 3). On an average, 15 per cent more increase in the grain yield (62.12 q ha^{-1}) due to 30 kg $ZnSO_4$ ha^{-1} was recorded over control (54.23 q ha^{-1}). Application of $FeSO_4$ even up to 10 kg ha^{-1} failed to influence the grain yield of rice. In rice fields, generally the conditions are highly suitable for early supply of $FeSO_4$ form of Fe and under such conditions any additional dose of ferrous sulphate might not be effective. Dravid and Goswami (1987) also holds the similar view.

Residual effect on yield attributes and wheat yield

Application of 40 kg $ZnSO_4$ ha^{-1} to preceding rice resulted an appreciable improvement in ear bearing shoots m^{-2} and in the grain and straw yield of

Table 1. Growth characters of hybrid rice as affected by levels and mode of application of $ZnSO_4$ and $FeSO_4$

Treatment	Tiller number m^{-2} at harvest		Dry matter production ($q\ ha^{-1}$) at harvest		Leaf area index at harvest		Crop growth rate from heading to harvest ($g\ m^{-2} d^{-1}$)	
	1999	2000	1999	2000	1999	2000	1999	2000
$ZnSO_4$ ($kg\ ha^{-1}$)								
10	15.21	15.70	145.32	152.17	6.60	6.82	9.9	9.6
20	17.18	17.61	151.33	158.56	7.46	7.68	10.2	10.1
30	18.63	19.16	156.81	164.33	8.09	8.31	10.8	10.9
40	18.66	19.41	158.70	166.89	8.13	8.34	11.2	11.1
C.D. at 5%	0.955	0.790	6.89	7.88	0.34	0.33	0.56	0.45
$FeSO_4$ ($kg\ ha^{-1}$)								
5	17.23	17.70	151.89	159.24	7.48	7.70	10.6	10.3
10	17.58	18.00	153.68	160.98	7.63	7.85	10.8	10.5
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Mode of application								
Incubated	17.49	17.90	153.29	160.58	7.59	7.82	10.7	10.3
Non-incubated	17.30	17.51	152.29	159.64	7.52	7.72	10.2	10.2
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Control	14.20	14.40	140.04	145.47	6.17	6.25	9.13	8.85
C.D. at 5%	1.36	0.940	7.11	10.08	0.17	0.11	0.47	0.30

Table 2. Yield attributes, grain and straw yield of hybrid rice as affected by levels and mode of application of $ZnSO_4$ and $FeSO_4$

Treatment	No. of panicles m^{-2}		No. of grains $panicle^{-1}$		Wt. of grains $panicle^{-1}$ (g)		Grain yield (q ha^{-1})		Straw yield (q ha^{-1})	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
$ZnSO_4$ (kg ha^{-1})										
10	497.0	507.1	109.3	108.5	3.52	2.62	58.40	55.62	90.19	93.76
20	528.3	545.0	111.1	110.0	3.68	3.77	60.78	57.89	95.43	98.12
30	579.6	592.0	113.5	112.7	3.93	3.96	63.86	60.37	98.50	103.20
40	584.8	598.1	113.7	113.0	3.95	3.99	64.40	61.39	99.32	104.10
C.D. at 5%	25.2	31.7	2.78	2.1	0.22	0.20	2.76	2.36	3.79	4.42
$FeSO_4$ (kg ha^{-1})										
5	537.1	553.6	111.5	110.6	3.57	3.69	61.08	58.18	93.97	93.13
10	540.7	558.0	112.3	111.5	3.61	3.74	61.74	58.81	94.88	99.23
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mode of application										
Incubated	570.1	586.0	112.6	112.7	3.62	3.72	61.62	58.70	94.72	98.93
Non-incubated	537.8	554.6	110.3	110.0	3.58	3.70	61.20	58.29	94.10	98.40
C.D. at 5%	25.0	23.0	1.7	1.3	NS	NS	NS	NS	NS	NS
Control	448.4	462.1	106.3	105.0	3.43	3.54	55.53	52.94	87.00	89.94
C.D. at 5%	53.8	65.5	5.2	6.3	0.160	0.030	5.49	4.87	7.82	9.10

Table 3. Residual effect of $ZnSO_4$ and $FeSO_4$ on number of ear bearing shoots m^{-2}, grain and straw yield (q ha^{-1}) of wheat

Treatment	No. of ear bearing shoots m^{-2}		Grain yield (q ha^{-1})		Straw yield (q ha^{-1})	
	1999	2000	1999	2000	1999	2000
$ZnSO_4$ (kg ha^{-1})						
10	346.8	335.3	40.23	41.93	48.72	50.61
20	354.7	341.5	40.95	42.69	49.29	51.73
30	374.5	368.2	42.07	43.87	50.83	53.01
40	388.9	373.3	42.93	44.67	51.52	53.92
C.D. at 5%	15.9	17.8	1.24	1.50	1.67	1.81
$FeSO_4$ (kg ha^{-1})						
5	363.4	350.4	41.28	43.07	50.44	52.00
10	371.5	359.7	41.76	43.57	51.74	52.63
C.D. at 5%	NS	NS	NS	NS	NS	NS
Mode of application						
Incubated	367.8	358.8	41.69	43.46	50.15	52.55
Non-incubated	362.1	350.3	41.38	43.11	50.03	52.09
C.D. at 5%	NS	NS	NS	NS	NS	NS
Control	335.0	324.4	39.12	40.77	47.54	43.74
C.D. at 5%	32.8	41.4	2.55	3.03	3.46	3.15

succeeding wheat. The mean quantum of increase in the grain yield due to 40 kg $ZnSO_4$ ha^{-1} was 43.75 q ha^{-1} whereas it was 39.95 q ha^{-1} only under control (Table 3). This jump in grain yield was mainly due to the improvement in the growth and yield attributing characters and sustained release of Zn which in turn resulted increased grain and straw yields (Khan *et al.* 1986). Application of $FeSO_4$ @ 5 and 10 kg ha^{-1} to preceding rice failed to enhance the grain yield of wheat over control. This might be due to the lack of availability of sufficient quantity of Fe in the field to the wheat crop (Prasad and Power, 1997).

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Ann. agric. Res. New Series Vol. **24** (2) : 227-233 (2003)

HETEROSIS AND COMBINING ABILITY FOR SOME QUALITY TRAITS IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT

Heterosis and combining ability studies were made on six grain quality characters. Heterosis over better parent was observed for cooking and milling characters, whereas mid-parental heterosis was noticed for all the quality traits. Predominance of additive gene action was observed for kernel length and L/B ratio, while hulling percentage. kernel elongation and volume expansion after cooking were under the influence of non-additive gene action. Equal importance of additive and non additive gene actions was noticed in case of kernel breadth. The parents, Lunisree, Erramallelu and Shiva for kernel length and L/B ratio and WGL-NDL-2 and RDR-763 for kernel elongation and volume expansion ratio were identified as good general combiners. The per se performance of the parent was found to be good indicator of their general combining ability.

Key words : Heterosis, combining ability, rice grain quality.

With the introduction of fertilizer responsive semi-dwarf varieties, there had been a spectacular increase in rice yields in mid 60's. Production figures for 1998-99 indicate that rice accounts for 84 million tones out of 202 million tones of food grain production, which is more than 42 percent of the total. This has enabled the country not only to do away with the imports, but also to accumulate 16 million tones buffer stock and export sizeable quantity of 5.6 million tones in 1995-96 (Paroda, 1998). On the other hand, there is a lot of demand for non Basmati long slender grain types as a result of increase in the socio-economic status of many people in India and growing awareness among consumers for quality rice which commands premium price in national and international markets. Hence, development of high yielding varieties with good physical qualities of grains viz., shape, size, appearance and good cooking qualities like kernel elongation and volume expansion after cooking are of more important. The information on grain quality characters could be better utilized for improving these traits. Assessment of combining ability and heterosis of quality traits serves as tool for the breeders in identifying better parents, hybrid combinations and to suggest an appropriate breeding strategy for bringing out improvement in grain quality. Keeping these factors in view, the present investigation was undertaken.

MATERIALS AND METHODS

Seven rice varieties viz., IR-20, Shiva, Tallahamsa, Lunisree, WGL-NDL-2, Erramallelu and RDR-763 were crossed in 7 × 7 diallel fashion without reciprocals. The resultant 21 F_1 hybrids were raised along with their parents in a randomized block design during rabi 99-2000 replicating thrice at Agricultural Research Station, Warangal. Each entry was grown in 2 rows of 3m long, adopting a spacing of 20 × 15 cm. The seeds were collected on randomly selected 10 plants in each replication. The physical grain quality characters viz., kernel length, kernel breadth were recorded using dial micrometer and then kernel L/B ratio was calculated. Huler of Satake, make Japan was used to estimate hulling percentage. Data on cooking quality characters viz., kernel elongation ration and volume expansion ratio were recorded following standard method suggested by Verghese (1950) and Murthy (1965) Method II and Model - I.

RESULTS AND DISCUSSION

Analysis of variance revealed that there were significant differences among the parents and hybrids for all the six characters studied. Combining ability analysis revealed that mean squares due to general combining ability (gca) and specific combining ability (sca) were significant for all the characters indicating there by importance of both additive and non-additive gene actions (Table 1).

Physical grain characters

Higher gca variance indicated the preponderance of additive gene action for kernel length and L/B ratio. Similar results were also reported earlier by Paramasivam et. al. (1996) and Geetha et. al. (1998). Analysis of mean performance of the parents and their sca effects (Table 2) revealed that per se performance of the parents is a direct reflection of their respective gca effects in most of the cases. As such, the good general combiners, which can be utilized as potential donors for increasing kernel length and L/B ratio are Lunisree, Erramallelu and Shiva.

The crosses with highly significant sca effects (Table 3) and high per se performance viz., Shiva/Tellahamsa, Shiva/Erramallelu, Shiva/Lunisree and Lunisree/

Table 1. Combining ability analysis

Source	d.f.	Hulling recovery	Kernel length	Kernel breadth	Length/breedth ratio	Kernel elongation ratio	Volume expansion ratio
GCA	6	3.917**	1.5000**	0.074**	0.337**	0.040**	0.434**
SCA	21	0.951*	1.043**	0.009**	0.022**	0.008**	0.100**
Error	54	0.194	0.001	0.0004	0.0007	0.0008	0.012
σ^2GCA		0.431	0.166	0.008	0.037	0.004	0.046
σ^2SCA		0.757	0.041	0.008	0.022	0.007	0.087
σ^2GCA/σ^2SCA		0.546	3.977	0.943	1.682	0.557	0.534

*Significant at 5% level **Significant at 1% level

Table 2. Estimates of mean and general combinibing ability effects

Parents	Hulling recovery		Kernel length		Kernel breadth		Length/breadth ratio		Kernel elongation ratio		Volume expansion ratio	
	Mean (%)	sca	Mean (mm)	sca	Mean (mm)	sca	Mean	sca	Mean	sca	Mean	gca
IR-20	83.1	0.316	5.53	-0.415	2.13	0.068**	2.59	-0.297	1.89	0.026	4.53-	0.049
Shiva	78.6	-0.803	6.50	0.228**	2.02	0.038**	3.20	0.044**	1.71	-0.044	4.46	0.029
Tellahamsa	82.03	0.808**	6.44	0.166**	2.12	0.057**	3.03	-0.009	1.78	0.022	4.1	-0.152
Lunisree	79.40	-0.958	7.21	0.575**	2.14	0.115**	3.36	0.102**	1.8	-0.012	4.13	-0.141
WGL-NDL-2	80.33	-0.077	5.42	-0.455	1.74	-0.094	3.1	-0.082	1.81	0.078**	4.93	0.333**
Erramallelu	81.10	0.490*	6.62	0.271**	1.7	-0.118	3.89	0.331**	1.62	-0.121	4.26	-0.267
RDR-763	82.16	0.223	5.5	-0.37	1.8	-0.065	2.98	-0.089	1.83	0.052**	4.93	0.248**
SE±	0.62	0.207	0.05	0.018	0.02	0.009	0.03	0.013	0.04	0.013	0.15	0.052

*Significant at 5% level **Significant at 1% level

Erramallelu involving parents of high × high gca in indicative of involvement of additive gene action, which is fixable. Hence, selection of single plants can be effectively practised in segregating generations to achieve pure lines with high kernel length. In addition, the crosses Shiva/Tellahamsa and Shiva/Lunisree exhibiting similar behavior in the inheritance of L/B ratio would simultaneously be used for improvement.

Although, mid-parental heterosis was observed in 10 crosses for kernel length, heterobeltiosis was noticed in only 4 combinations (Table 4). For L/B ratio, both mid and better parental heterosis were in negative direction. Low and negative heterosis for these traits were also reported earlier by Singh and Singh (1985), Sahai *et al.* 1986, Reddy *et al.* (1991) and Chauhan and Chauhan (1995). Maximum heterobeltiosis (8.3%) for kernel length was recorded by Shiva/Tellahamsa. These results indicated lesser chances of exploitation through heterosis breeding.

Heterosis in negative direction is desirable to produce narrow kernels with increased L/B ratio. Accordingly, 4 hybrids viz., Tellahamsa/WGL-NDL-2, Tellahamsa/Erramallelu, IR-20/wgl-NDL-2 and Lunisree/Erramallelu exhibited significant negative heterobeltiosis in a range of -2.80 to -4.86 percent. The genotypes involved in these hybrids viz., Erramallelu, WGL-NDL-2 with low per se and high negative sca effects were identified as good combiners for low kernel breadth.

Milling characters

The trait hulling recovery was governed by non-additive gene action, as evidence by higher magnitude of sca variance

Table 3. Estimates of mean and specific combinibing ability effects

Parents	Hulling recovery		Kernel length		Kernel breadth		Length/breadth ratio		Kernel elongation ratio		Volumeexpansion ratio	
	Mean (%)	sca	Mean (mm)	sca	Mean (mm)	sca	Mean	sca	Mean	sca	Mean	gca
IR-20	80.4	-0.970	5.91	-0.171	2.17	-0.009	2.71	-0.059	1.71	-0.117	4.63	0.023
IR-20/Tellahamsa	82.76	-0.215	5.90	-0.118	2.23	0.039	2.63	-0.088	1.81	-0.080	4.26	-0.162
IR-20/Lunisree	81.20	-0.015	6.29	-0.137	2.24	-0.012	2.79	-0.036	1.88	0.027	4.83	0.394**
IR-20/WGL-NDL-2	82.70	0.637	5.63	0.236**	2.06	0.020	2.72	0.075*	2.10	0.157*	4.40	-0.514
IR-20/Erramallelu	82.20	-0.463	6.03	-0.093	2.11	0.090*	2.84	-0.215	1.67	-0.074	4.10	-0.214
IR-20 RDR-763	82.20	-0.196	5.57	0.092	2.10	0.028	2.64	0.005	2.02	0.103**	5.30	0.471**
Shiva/Tellahamsa	83.03	1.170*	7.04	0.385**	2.19	0.022	3.21	0.151**	1.96	0.137**	4.50	-0.006
Shiva/Lunisree	80.83	0.737	7.30	0.233**	2.21	-0.013	3.29	0.123**	1.75	-0.039	4.46	-0.051
Shiva/WGL-NDL-2	81.56	0.589	5.74	-0.300	2.08	0.063*	2.75	-0.236	1.87	-0.002	5.33	0.342**
Shiva/WGL-NDL-2	82.93	1.389*	7.05	0.291**	2.13	0.136*	3.30	-0.096	1.74	0.060	4.53	0.142
Shiva/Erramallelu	81.66	0.389	6.12	-0.005	2.09	0.047	2.92	-0.063	1.89	0.040	4.90	-0.006
Shiva/RDR-763	82.10	0.393	7.23	0.229**	2.27	0.025	3.18	0.063	1.83	-0.022	4.26	-0.069
Tellahamsa/Lunisree	83.30	0.711	5.79	-0.181	2.02	-0.012	2.86	-0.073	2.10	0.158**	5.46	0.0656**
Tellahamsa/WGL-NDL-2	83.83	0.678	6.80	0.103*	2.03	0.021	3.34	-0.009	1.73	-0.016	3.93	0.277
Tellahamsa/Erramallelu	83.03	0.144	5.95	-0.106	2.09	0.025	2.84	-0.086	1.95	0.034	5.03	0.308
Tellahamsa/RDR-763	80.83	0.011	6.41	0.027	2.30	0.213*	2.78	-0.267	1.96	0.056	5.06	0.245
Lunisree/WGL-NDL-2	81.36	-0.022	7.31	0.204**	2.08	0.013	3.50	0.046	1.71	-0.002	4.06	-0.155
Lunisree/Erramallelu	81.60	-0.022	6.32	-0.0148	2.21	0.091*	2.85	-0.187	1.89	0.008	4.80	0.064
Lunisree/RDR-763	83.63	1.363*	5.94	-0.139	1.86	-0.001	3.19	-0.084	1.77	-0.032	5.00	0.305*
WGL-NDL-2/RDR-763	81.43	-0.570	5.65	0.216**	1.90	-0.007	2.96	0.107**	2.00	0.031	4.90	-0.310
Erramallelu/RDR-763	83.10	0.530	6.17	0.003	1.90	0.016	3.23	-0.039	1.80	0.024	4.46	-0.144
SE+	0.62	0.549	0.05	0.048	0.02	0.025	0.03	0.034	0.04	0.035	0.15	0.138

*Significant at 5% level **Significant at 1% level

Table 4. Estimates of heterosis (H_1) and heterobeltiosis (H_2)

Parents	Hulling recovery		Kernel length		Kernel breadth		Length/breadth ratio		Kernel elongation ratio		Volumeexpansion ratio	
	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2
IR-20	-0.56	-3.25	-1.83	-9.17	4.41*	1.88	-6.32	-15.28	-5.18	-9.52	2.96	2.21
IR-20/Tellahamsa	0.24	-0.40	-1.48	-8.43	5.09*	5.01*	-6.34	-13.09	1.27	-4.06	-1.16	-5.88
IR-20/Lunisree	-0.06	-2.29	-1.31	-12.80	4.99*	4.67*	-6.05	-16.77	2.07	-0.18	11.54	6.62
IR-20/WGL-NDL-2	1.24	-0.44	2.80*	1.81	6.62*	-2.97	-4.39	-12.24	13.67**	11.46**	-7.04	-10.81
IR-20/Erramallelu	0.12	-1.08	-0.80	-8.96	10.36*	-0.78	-12.19	-26.82	-4.55	-11.29	-6.82	-9.54
IR-20 RDR-763	-0.52	-1.08	1.03	0.72	5.87*	-1.25	-5.02	-11.19	8.96**	7.23**	11.97**	7.43*
Shiva/Tellahamsa	3.38**	1.22	8.83*	8.30*	5.46*	2.98**	3.05*	0.21	12.0**	9.91**	5.06	0.75
Shiva/Lunisree	2.32**	1.81*	6.46*	1.25	6.16*	3.27**	0.41	-1.88	-0.66	-3.14	3.88	0.00
Shiva/WGL-NDL-2	2.64**	1.54	-3.80	-11.78	10.25*	2.63	-12.73	-14.14	6.23**	3.30	13.48**	8.11*
Shiva/WGL-NDL-2	3.86**	2.26**	7.49*	6.54*	14.31*	5.10*	-6.81	-15.00	4.19	1.36	3.82	1.49
Shiva/Erramallelu	1.60*	-0.61	1.94**	-5.94	8.18*	3.29**	-5.60	-8.94	6.77**	3.46	4.26	-0.68
Shiva/RDR-763	1.71*	0.08	5.98*	0.32	6.32*	5.91*	-0.37	-5.26	2.14	1.48	3.64	3.23
Tellahamsa/Lunisree	2.61**	1.54*	-2.33	-10.04	4.48*	-4.86	-6.63	-7.73	16.85**	15.78**	21.03**	10.81**
Tellahamsa/WGL-NDL-2	2.78**	2.19**	4.18*	2.77*	6.27*	-4.39	-3.47	-14.14	1.57	-2.99	-5.98	-7.81
Tellahamsa/Erramallelu	1.14	1.05	-0.25	-7.55	5.29*	-1.72	-5.38	-6.16	8.12**	6.74**	11.44**	2.03
Tellahamsa/RDR-763	1.21	0.62	1.48	-11.09	18.59*	7.62*	-13.98	-17.26	8.56**	8.26**	11.76	2.70
Lunisree/WGL-NDL-2	1.39*	0.33	5.76*	1.43	8.41*	-2.80	-3.26	-9.85	-0.29	-5.35	-3.17	-4.69
Lunisree/Erramallelu	0.39	-1.30	-0.52	-12.34	11.04*	3.27**	-9.99	-15.08	4.12*	3.46	5.88	-2.70
Lunisree/RDR-763	3.61**	3.12**	-1.36	-10.27	7.93*	6.49*	-8.77	-17.99	2.91	-2.57	8.70**	1.35
WGL-NDL-2/RDR-763	0.23	-0.89	3.54*	2.85*	6.22*	3.44**	-2.58	-4.51	10.05**	9.65**	-0.68	-0.68
Erramallelu/RDR-763	1.80**	1.14	1.79**	-6.84	7.62*	3.44**	-5.97	-16.97	4.25*	-1.64	-2.90	-9.46
SE±	0.53	0.62	0.04	0.05	0.02	0.03	0.03	0.04	0.03	0.04	0.13	0.15

*Significant at 5% level **Significant at 1% level

(Vivekanandan and Giridharan, 1997 and Sharma and Mani, 1998).

Heterosis over mid and better parents was observed mostly in positive direction and highest value of 3.86% was associated with the cross, Shiva/Erramallelu. The best crosses (Sghiva/Erramallelu, WGL-NDL-2/ Erramallelu and Shiva/Tellahamsa) with high sca effects, per se performance and significant heterobeltiosis involving parents of low × high gca represent nonfixable genetic component, as such population improvement with recurrent or reciprocal recurrent selection would be highly rewarding.

Cooking characters

It is ultimately the cooking quality, which determines the success of a variety from the trade and consumption point of view. As such of rice is consumed as cooked rice in India and other rice growing countries, cooking qualities like kernel elongation and volume expansion after cooking are of paramount importance.

SCA variance was higher than that of gca for kernel elongation and volume expansion ratio, which indicated the influence of non-additive genetic component in their expression. Murthy (1994) also reported preponderance of non-additive gene action for volume expansion ratio. The parents RDR-763 and WGL-NDL-2 with high mean values and gca effects were identified as good general combiners for improving cooking qualities. The promising crosses for kernel elongation ratio (IR-20/ WGL-NDL-2, Tellahamsa/WGL-NDL-2, Shiva/Tellahamsa and IR-20/RDR-763) and volume expansion ratio (Tellahamsa/WGL-NDL-2, Shiva/WGL-NDL-2 and IR-20/ RDR-763) with high sca effects, heterobeltiosis and per se performance involved parents of mostly low × high or medium × high gca. Such crosses involving non-additive genetic components can not be directly selected upon, and therefore can be exploited through heterobeltiosis or hybridization and selection. In future generations, H×L combinations offer opportunity to practice selection on the transgressive segregants in the desired direction (Langham, 1961).

The study revealed that the parents Lunisree and Erramallelu and hybrid combinations Shiva/Tellahamsa, Shiva/ Lunisree, Shiva/Erramallelu and Lunisree/ Erramallelu are suitable for improvement of physical grain quality traits. The hybrid combinations Tellahamsa/WGL-NDL-2 and IR-20/RDR-763 can be exploited through non-additive genes and the donors for good cooking quality are WGL-NDL-2 and RDR-763.

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EVALUATION OF MANGO GENOTYPES FOR THEIR FLOWERING, FRUITING AND FRUIT QUALITY ATTRIBUTES

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ABSTRACT

Twenty mango genotypes were evaluated for their flowering, fruiting, and fruit quantity attributes during 1997 and 1998 under Bihar conditions. Maximum panicle length (21.30 cm) was found in Safed Bathua followed by Rangraj and Dadamiyan. However, highest percentage of hermaphrodite flowers were recorded in Bag Bahar. Nazara Bombai has been found earliest in maturity period. Safed Bathua matured at the last followed by Kalapahar, Gilas and Dadamiyan. Rest of the genotypes matured in-between. Maximum yield per plant was recorded in Dudhiya Maldah (155.00 kg) followed by Nazara Bombai, Dadamiyan, Culcuttia Maldah and Safed Bathua. Maximum pulp, TSS, sugars and total carotenoid content was found in Dudhiya Maldah followed by Calcuttia Maldah and Dadamiyan.

Key words : Panicles, hermophrodite flowers, fruit yield, maturity period, pulp percentage, TSS, sugars and total carotenoid content.

Mango (*Mangifera indica* L.) is the national fruit of India. It has several varieties grown in various parts of the country (Singh and Chadha, 1981, Ghosh *et al*; 1985, Sharma and Josan, 1995, Kumar, 1997 and Mitra *et al*; 2001). Lot of emphasis has been paid to mango improvement through inter varietal hybridization (Chadha, 1989). Although, a large number of mango cultivars are being grown in Bihar, but most of them do not satisfy the requirements of an ideal commercial cultivar. Regulation of marketing for consumer acceptability and greater remuneration, it becomes imperative to study the performance of different leading genotypes under Bihar conditions. Keeping above facts in view, present studies were carried out to have the information regarding flowering, fruiting and fruit quality attributes of different genotypes.

MATERIALS AND METHODS

Fifteen year old different mango genotypes namely Nazara Bombai, Karpuria, Kanchan Lal, Lalmarai, Bag Bahar, Baramasia, Latkampoo, Rarhi, Calcuttia Maldah, Dadamiyan, Safed Bathua, Hathijhula, Kalapahar, Dudhiya Maldah, Ambalabi, Gilas, Gulabkhas, Rangraj, Police, Chaprah were evaluated in the experimental orchard of department of Horticulture BAC Sabour during the year 1997 & 1998 in randomized block design with four replications. Data for two years were pooled and analyzed. Planting was done at a distance of 10 × 10 meter and uniform cultural practices were provided. Performance of each genotype was evaluated in terms of flowering, fruiting and fruit quality parameters. The TSS and titratable acidity were determined by standard methods. Ascorbic acid and sugars were determined as per AOAC, 1980. Analysis of total carotenoids was done as per the method suggested by Roy, 1973.

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RESULTS AND DISCUSSION

Peak panicle emergence was recorded at the earliest in Calcuttia Maldah and Gulab Khas i.e. on 17th February followed by Kanchan Lal, Gilas and Hathijhula, whereas it was noted at the last in Latkampoo i.e. 27th February (Table-1). It is evident from the Table-1 that peak period of flowering was noticed at the earliest (20/3) in Hathijhula followed by Calcuttia Maldah, Kanchan Lal, Gilas and Kala Pahar and latest (24/3) in Karpuria and Latkampoo. There was marked variation in average panicle length in most of the genotypes and Safed Bathua was on the top with 2130 cm followed by Dadamiyan (20.20 cm) and Rangraj (20.40). Least panicle length was found in Karpuria (13.00 cm). The earliest completion of fruit set was observed in Gilas (30/3) while it was recorded at the last in Dudhiya Maldah (Table-I). Wide range of variation in percent hermaphrodite flowers was observed throughout the experimentation in different genotypes. Table 1 reveals that maximum percentage of hermaphrodite flowers was noted in Bag Bahar (35.00%). Fruit set per panicle was found to be highest in Dudhiya Maldah (63.20). Nazara Bombai matured at the earliest and Safed Bathua at the last in both years of experimentation while rest of the genotypes matured in between. Dadamiyan proved to be medium late genotype under Sabour conditions. Variation in following, fruiting and fruit authority in different genotypes might be due to change in location or inherent genetic variations. Similar results were obtained by Sharma and Josan, 1995 and Chaudhary and Desai, 1996 in mango. Maximum fruit yield per plant was recorded in Dudhiya Maldah (155.00 kg) followed by Nazara Bombai, Dadamiyan, Calcuttia Maldah and Safed Bathua, while least fruit yield per plant (70.25 kg) was found in Baramasia (Table-1). Differences in fruit yield in different genotypes have also been observed by Srivastava et al 1987, Teaotia and Singh, 1991 and Sharma and Josan 1995 in mango.

Culcuttia Maldah fruits were maximum in fruit weight (262.50 gm) followed by Dudhiya Maldah, Ddamiyan and Kala Pahar while minimum fruit weight (142.50 gm) was recorded in Safed Bathua (Table-2). These findings are in accordance with findings of Kumar, 1997 and Mitra et al 2001 in mango. Dudhiya Maldah recorded maximum pulp content (67.20%) followed by Calcuttia Maldah and Dadamiyan, while it was minimum in Hathijhula (51.00%). Table 2 reveals that TSS, total sugar, reducing sugar and total cerotenoid content were found to be maximum in Dudhiya Maldah i.e. 20.34%, 15.70%, 3.90% and 4.92 mg/100g respectively. It was followed by calcuttia Maldah and Dadamiyan. However, ascorbic acid content was found

Table 1. Flowering and fruiting behavior of different mango germplasm

Mango genotypes	Date of Panicle emergence	Date of flowering	Average panicle length (cm)	Date of fruit set	Hermaphrodite flowers (%)	Fruit set/ panicle	Maturity time	Yield per plant (Kg)
Nazara Bombai	19/2	23/3	15.00	6/4	14.50	46.70	3/6	153.00
Karpuria	24/2	24/3	13.00	3/4	19.00	39.33	10/6	102.60
Kanchan Lal	18/2	21/3	14.50	2/4	17.5	38.15	20/6	120.15
Jalmarai	23/2	23/3	15.60	1/4	17.00	13.44	17/6	107.60
Bag Bahar	22/2	23/3	14.20	1/4	35.00	40.13	15/6	130.00
Baramasia	24/2	18/3	16.90	2/4	22.00	33.73	25/6	70.25
Latkampoo	27/2	24/3	18.50	1/4	15.00	40.08	3/6	102.50
Rarhi	23/2	18/3	18.60	31/4	19.00	48.50	2/6	106.00
Calcuttia Maldah	17/2	21/3	19.70	5/4	20.00	23.80	20/6	144.00
Dadamiyan	24/2	23/3	20.20	4/4	16.00	35.00	29/6	145.25
Safed Bathua	21/2	21/3	21.30	6/4	23.00	20.32	15/6	140.00
Hathi Jhula	20/2	16/3	19.30	2/4	20.00	35.00	30/6	123.00
Kala Pahar	22/2	20/3	15.00	11/4	13.50	18.90	4/6	142.50
Dudhia Maldah	21/2	19/3	15.00	7/4	14.50	63.20	18/6	155.00
Ambalabi	20/2	17/3	13.50	3/4	17.50	32.10	18/6	122.50
Gilas	18/2	17/3	16.70	30/4	18.50	20.31	4/6	116.00
Gulabkhas	17/2	21/3	18.50	2/4	16.50	45.69	8/6	132.50
Rangraj	19/2	18/3	20.40	2/4	15.00	27.32	16/6	97.75
Police	22/2	20/3	13.50	4/4	14.00	26.00	29/6	126.50
Chaprah	23/2	19/3	17.50	5/4	20.50	35.12	25/6	132.50
C.D. (p=0.05)	-----	-----	1.94	-----	1.92	4.29	-----	8.39

contd...

Mango genotypes	Fruit weight (gm)	Pulp(%)	Peel (%)	TSS(%)	Acidity (%)	Ascorbic acid (mg/100g)	Total sugar (%)	Reducing Sugar(%)	Total Carotenoid (mg/100g)
Nazara Bombai	191.10	61.65	20.50	19.65	0.24	50.00	14.89	3.17	3.16
Karpuria	175.05	59.11	21.25	20.00	0.25	44.00	15.28	2.89	3.37
Kanchan Lal	178.65	56.83	21.75	18.85	0.28	44.64	15.09	2.62	3.53
Jalmarai	192.50	52.55	21.24	19.40	0.20	40.63	14.90	2.32	3.17
Bag Bahar	207.50	61.50	18.91	20.00	0.26	48.50	14.82	2.97	3.43
Baramasia	137.50	52.50	19.25	18.25	0.28	42.56	14.69	2.87	2.87
Latkampoo	192.50	55.50	22.25	17.95	0.33	44.50	15.07	3.12	3.49
Rarhi	182.50	52.73	21.25	18.26	0.32	46.00	15.12	3.64	3.27
Calcuttia Maldah	262.50	66.56	17.16	19.87	0.24	47.00	15.52	3.73	4.66
Dadamiyan	252.50	66.13	19.85	19.60	0.30	47.13	15.42	3.67	4.75
Safed Bathua	142.50	59.10	22.75	16.06	0.28	65.20	14.06	2.80	3.49
Hathi Jhula	211.30	52.43	22.83	19.16	0.23	41.70	15.06	3.06	3.54
Kala Pahar	207.75	54.50	21.25	19.76	0.25	42.67	15.20	3.12	2.90
Dudhia Maldah	257.50	67.20	18.30	20.34	0.23	53.50	15.70	3.90	4.92
Ambalabi	176.50	62.66	20.39	18.85	0.28	48.76	14.10	3.08	2.25
Gilas	192.60	61.50	19.65	18.44	0.29	44.40	14.18	2.67	2.52
Gulabkhas	206.45	55.50	20.06	19.42	0.30	44.25	14.90	2.85	4.12
Rangraj	209.05	58.25	20.86	18.30	0.26	43.46	14.29	2.52	2.48
Police	192.70	58.10	21.25	19.06	0.23	42.50	14.55	2.48	2.52
Chaprah	165.40	62.67	22.05	18.39	0.26	42.15	14.06	2.61	2.16
C.D. (p=0.05)	3.94	2.13	2.11	0.86	0.04	2.87	1.13	0.22	0.23

to be maximum (65.20mg/100g) in Safed Bathua The varietal differences in fruit quality attributes have also been observed by Kumar 1997, Mitra et al, 2001 and Kumar and Singh 2001 in mango. In view of the overall performance Nazara Bombay Dudhiya Maldah and Dadamiyan had much potential for cultivation under Bihar conditions as early, medium and late varieties, respectively. Hence, these may be recommended for this region.

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IMPACT OF PAPER MILL EFFLUENT AND DISTILLERY EFFLUENT IRRIGATION ON YIELD AND NUTRIENT UPTAKE OF RICE

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ABSTRACT

The disposal of distillery effluent (PME), a distillery waste, and paper mill effluent has long been a problem of the agro-based industries. Pot culture experiment was conducted to find out suitability of these effluents for irrigation purpose. Complete saturation of the soil with these two effluents, used separately and in combination, twenty days before rice (var. Pusa 44 and CSR 10) transplanting showed better responses in growth and yield attributes of rice. Application of distillery effluent enhanced the nutrient content and nutrient uptake in rice. Nitrogen and Phosphorus content and uptake increased on application of paper mill effluent. But application of paper mill effluent inhibited potassium uptake in rice. CSR 10, a salt tolerant rice variety showed an overall better growth and yield than Pusa 44, a sensitive variety, after effluent irrigation treatment.

Key words : Paper mill effluent, distillery effluent, irrigation, rice.

Post methanation distillery effluent (PME) is characterized by its extremely large volume, putrefying odor, dark coffee colour, highly biodegradable character, dissolved solid content that present significant disposal or treatment problems. Paper mill effluent is characterized by conventional pollutants like high BOD, suspended solids, COD, and pH, whereas non-conventional pollutant is coloured, mainly due to lignin and its derivatives. Therefore, not only the suitable measures are imperative to restrain the entry of such highly organic effluent into the watercourses, the useful organic matter and the nutrients present in the effluents should not be wasted. Considering the limitations of various technologies in achieving adequate treatment of the effluent for its discharge into the watercourses the application of effluent on land as irrigation water, source of plant nutrient offers a promising alternative. Industrial wastewater could be safely and effectively used to increase crop productivity. The utilization of industrial wastes for agricultural purposes could also provide solution to the disposal problems. The present study was envisaged to explore the possibility of using these effluents as a source of nutrients for crop plants, which may play an important role in the context of scarcity of fresh water resources for irrigating agricultural land.

MATERIALS AND METHODS

To realize the set out objective the pot culture experiment was conducted at Division of Environmental Sciences, Indian Agricultural Research Institute, New Delhi. Soil was collected from the adjoining farm area of Indian Agricultural Research Institute, New Delhi. The soil was completely saturated with effluents (4 litre/pot) twenty days before rice transplanting. Air dried soils were sieved through 2 mm sieve and in each pot 10 kg of soil was taken. Rice varieties, Pusa 44 and CSR 10 were grown during 2000 Kharif season. A constant 5 cm standing water was maintained through out the cropping season. Plant samples were collected at harvest for laboratory analysis.

Treatments : Five treatments were taken with four replications each for both the varieties of rice. The treatments were :

1. Control with only water.
2. 50% paper mill effluent +50% water.
3. 20% distillery effluent + 80% water.
4. 50% paper mill effluent + 20% distillery effluent.
5. 25% paper mill effluent + 20% distillery effluent

FERTILIZER

Commercial grade urea (46.6% N), DAP (18:46:0) and MOP (60% K_2O) were added to supply N, P and K respectively in the pots. The dose of fertilizers were 120 : 60 : 60 - N, P and K, respectively for rice. Nitrogenous fertilizer was added in three split doses i.e. as basal application, at tillering stage and at preflowering stage. Total phosphatic and potassic fertilizer was applied as basal dose.

RESULTS AND DISCUSSION

The physicochemical composition of paper mill effluent and distillery effluent is given in Table 1. Results emanating from

Table 1. Physico-chemical characteristics of distillery and paper mill effluent

Characteristics	Distillery	Paper Mill
Colour	Dark brown	Brown
Odor	Pungent	Not pungent
EC	8.5(dS/m)	2.16(dS/m)
pH	7.1	7.92
BOD	5600(mg/l)	68(mg/l)
COD	26775(mg/l)	258(mg/l)
Potassium	3760 (mg/l)	74 (mg/l)
Calcium as CaO	1200 (mg/l)	240 (mg/l)
Magnesium	620 (mg/l)	400 (mg/l)
Chloride	2000 (mg/l)	175 (mg/l)
Total nitrogen	495 (mg/l)	50 (mg/l)
Phosphorus	10 (mg/l)	1.5 (mg/l)

the study showed that addition of effluents to the soils have significantly increased the growth and yield of the crops (Table 2). When distillery effluent (PME) was added alone the, nutrient content and uptake increased significantly over control and only paper mill effluent treated soil at 5% level of significance. It may be due to fact that PME contains higher amount of macronutrients than paper mill effluent. Robian et al. (1986) reported similar results on yield of sugarcane, zalawadia et al. (1994) on sorghum and Singh (1992) on maize, wheat and mustard. When Pusa 44 grown without effluent treatment, lesser grain yield was recorded and crop growth was poor. CSR 10 a tolerant variety have shown better growth and yield than Pusa 44. This may be due to the varietal differences between the two varieties. Distillery effluent treated pots responded better than paper mill effluent treated pots. In mixed effluent treatments 50% paper mill effluent + 20% distillery effluent showed better results than the soil treated with 25% paper mill effluent and 20% distillery effluent. It may be due to the fact that the effluents contain higher amount of nutrients and also some amount of micronutrients.

Pusa 44 variety of rice up took significantly more potassium than CSR-10 variety. Among the mixed effluent treatments, the plants grown in the treatment with 50% paper mill effluent + 20% distillery effluent removed more nitrogen from soil and performed better than the other treatment (25% paper mill effluent + 20% distillery effluent). This can be attributed to the presence of nitrogen, in higher amounts, in mixed effluents, which helped in overall better growth and development of the crops in mixed effluent treated pots.

Only distillery effluent treated pots up took more phosphorus than only paper mill effluent treated pots. This may be due to

Table 2. Effect of different treatments on yield of rice

Treatments	CSR 10			PUSA 44		
	Test weight (g)	grain yield (g pot^{-1})	Biomass yield (g pot^{-1})	Test weight (g)	grain yield (g pot^{-1})	Biomass yield (g pot^{-1})
Control	18.0	16.1	72.48	19.5	14.9	75.39
50% paper mill	22.0	16.8	76.83	20.6	15.3	79.76
20% Distillery	22.4	17.5	79.25	22.3	15.8	80.77
50% paper mill +20% Distillery	22.8	18.0	83.35	22.6	16.3	80.93
25% paper mill +20% Distillery	22.3	17.3	79.75	21.9	15.9	79.99
C.D. at 5%	0.36	0.49	1.3	0.22	0.29	0.73

P 30823

Table 3a. Effect of treatments on nutrient content on rice variety CSR10

Treatments	Nitrogen (%)		Phosphorus(%)		Potassium(%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Control	1.40	0.696	0.194	0.097	0.395	1.63
50% paper mill	1.48	0.725	0.355	0.150	0.306	1.41
20% Distillery	1.70	0.758	0.392	0.159	0.576	2.23
50% paper mill +20% Distillery	1.90	0.788	0.453	0.185	0.336	1.47
25% paper mill +20% Distillery	1.85	0.769	0.410	0.169	0.363	1.58
C.D. at 5%	0.04	0.009	0.008	0.009	0.04	0.007

Table 3b. Effect of treatments on nutrient content on rice variety Pusa 44

Treatments	Nitrogen (%)		Phosphorus(%)		Potassium(%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Control	1.51	0.702	0.262	0.115	0.407	1.67
50% paper mill	1.54	0.740	0.368	0.155	0.346	1.43
20% Distillery	1.75	0.770	0.383	0.173	0.607	2.35
50% paper mill +20% Distillery	1.90	0.794	0.444	0.189	0.371	1.52
25% paper mill +20% Distillery	1.86	0.781	0.411	0.181	0.393	1.58
C.D. at 5%	0.02	0.008	0.009	0.003	0.007	0.02

the presence of higher amount of phosphorus in distillery effluent than in paper mill effluent. Higher amount of phosphorus was uptaken from the upto where 50% paper mill effluent was incorporated with 20% distillery effluent than the pots where 25% paper mill effluent was added with 20% distillery effluent. CSR 10 variety up took less phosphorus than Pusa 44 variety or rice.

The potassium uptake in the two contrasting varieties of rice was highest in distillery effluent treated pots. The potassium uptake by rice crop was lowest in the pots treated with only appear mill effluent. When the two effluents were combined the paper mill effluent inhibited the potassium uptake by both the varieties of the crop (Table 4). For both the varieties of rice crop, in the treatment where 50% paper mill effluent was added with 20% distillery effluent the potassium uptake was significantly lower than the treatment where only 20% distillery effluent was added to the soil. When proportion of paper mill effluent was reduced from 50% to 25% with 20% distillery effluent the potassium removal slightly increased, but it was still lower than the treatment where only distillery effluent was added to the soil.

From the present study it may be concluded that growth and yield of rice improved on application of effluents (separately or in combination). Nitrogen and phosphorus uptake was enhanced by effluent irrigation. Potassium uptake was inhibited by paper mill effluent irrigation.

Table 4. Effect of treatments on nutrient removal by Rice

	CSR10			PUSA 44		
Treatments	Nitrogen ($g\ pot^{-1}$)	Phosphorus ($g\ pot^{-1}$)	Potassium ($g\ pot^{-1}$)	Nitrogen ($g\ pot^{-1}$)	Phosphorus ($g\ pot^{-1}$)	Potassium ($g\ pot^{-1}$)
Control	0.618	0.085	0.982	0.649	0.108	1.070
50% paper mill	0.684	0.149	0.897	0.712	0.156	0.974
20% Distillery	0.766	0.166	1.477	0.777	0.173	1.622
50% paper mill +20% Distillery	0.857	0.202	1.021	0.823	0.194	1.042
25% paper mill +20% Distillery	0.800	0.176	1.049	0.796	0.181	1.075
C.D. at 5%	0.009	0.008	0.009	0.009	0.005	0.008

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INHERITANCE OF RESISTANCE TO BLACK ROT DISEASE IN LATE CAULIFLOWER

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ABSTRACT

Twenty five genotypes of cauliflower comprising of standard varieties and elite lines were evaluated for resistance to black rot (*Xanthomonas campestris pv compestris* (Pam) Dowson). The line SN-445 and BR-2 were found to be resistant where as variety PSB-1 and line Kj-38 were susceptible. Four crosses were attempted between susceptible and resistant parents. The parents, F_1, F_2 and back cross generations were again screened for presence of resistance to black rot through artificial inoculation in a randomized block design. Although the resistance was dominant but the additivity of the genes played a major role in the inheritance of the resistance with inter allelic interactions also affecting the expression of the resistance.

Key words : Cauliflower, *Xanthomonas*, resistance, segregating, gene affects.

Cauliflower (*Brassica oleracea* var. *botrytis* L.) occupies an important place among the cole crops in India. Out of 2,70,000 hectares under cauliflower in India, more than 25 percent is under snowball group (Anonymous, 1994). This group is grown mainly in Himachal Pradesh for curd as well as for seed purposes. The state not only meet the seed requirement of the country but also helps in exporting seed to Eastern and African countries. However, the cauliflower production in the state has been found to suffer due to many diseases like black rot, stalk rot, curd rot complex and downy mildew etc. mainly due to extensive and continuous cultivation of very limited number of cultivars of snowball group. Of all these diseases black rot (*Xanthomonas compestris pv compestris* (Pam) Dowson) has seriously threatened the curd and seed production of this crop in the state. The disease is favoured by warm temperature and high humidity, damages the crop right from the nursery stage to seed production stage and some times causes serious losses. The chemical control of this disease is available, but due to its health hazardous effects the only answer is the development of resistant varieties/hybrids. Therefore, keeping this in view an effort was made to work out the inheritance of the resistance to this disease through hybridization involving some resistance sources with horticulturally important but susceptible varieties.

MATERIALS AND METHODS

In the present studies 25 genotypes comprising of standard cultivars such as

PSB-1 PSBK-1, Snowball-16 and other elite lines were evaluated for disease resistance against black rot at Vegetable Research farm of the Dr. YS Parmar University of Horticulture and Forestry- Nauni, Solan (HP) during 1995-99. Subsequently after their evaluation the selected resistant sources BR-2 and SN-445 were crossed with PSB-1 a commercial variety and KJ-38 (an elite line with good curd quality characters). Besides F_1's, F_2 black cross generations were also developed. The parents, F_1s, F_2s and back cross generations were evaluated during 1997-99 for disease resistance and other horticultural characters in a randomized block design keeping three replications.

The genotypes were evaluated against black rot at the nursery stage and in the field one month after transplanting. The leaves of five plants in each replication were inoculated with 48 hours old culture of Xanthomonas by stubbing the mid rib at tip portion with tooth pick dipped in culture suspension having a concentration of 1×10^8 cfu/ml. The inoculations were done in the morning at dusk and inoculated plants were kept under high humidity conditions by frequently spraying water and providing irrigation for 5 days. The reaction of the genotypes, crosses and segregating generations was recorded after one month of inoculation on the basis of 0-9 scale as given by Williams et al. (1972). The disease index ratings of 0, 1 and 3 were rated as resistant and 5-9 as susceptible.

$$DI = \sum_{i=0}^{n} \frac{i \times j}{N}$$

where : i = IP classes

j = No. of plants/class

N = No. of plants observed

n = highest class

The mean disease index of six generations of four crosses was analyzed for estimating the components of generation means.

RESULTS AND DISCUSSION

Out of the 25 genotypes evaluated for the disease resistance majority showed the susceptible reaction. The genotypes KN-81, BR-2, SN-445, ACC-641, KK-104 and RSK-1301 were found to be resistant to black rot with average disease index rating less than 2. The genotypes BR-2 and SN-445 were used in the crossing programme as sources of resistance to black rot as the other resistant sources were either early bolters (ACC-641 and KK-104) or very late in flowering (KN-81). Both of these sources also produced good quality curds as compared to other four genotypes and moreover the genotypes SN-445 has been reported to carry a dominant gene for black rot resistance (Jamwal and Sharma, 1986). The commercial variety PSB-1 and elite line KJ-38 with good curd quality were highly susceptible to black rot and hence taken up in the crossing programme.

The generation means analysis (Table 1) of the parents, crosses and back crosses showed significant differences in the incidence of black rot disease. The F_1 were resistant and within the range of their parents. This indicated that the gene

Table 1. Generation means, scaling and gene effects studies

Generation means

Crosses	P1	P2	F1	F2	B1	B2
PSB-1 × SN-445	5.30	1.54	1.68(3.42)	2.31(2.55)	4.21(3.47)	1.83(1.61)
PSB-1 × BR-2	5.30	1.16	2.02(3.23)	3.19(2.39)	3.00(3.66)	1.46(1.59)
KJ-38 ×SN 445	3.93	1.54	2.31(3.73)	2.70(2.52)	1.14(3.12)	1.96(1.92)
KJ-38 × BR-2	3.93	1.16	1.60(2.54)	2.12(2.07)	3.81(2.76)	1.35(1.38)

SE ± 0.26

Scalling test

Crosses	A	B	C	Joint Scalling
PSB-1 × SN-445	1.44* ± 0.48	0.44 ± 0.2	-0.95 ± 0.4	24.25
PSB-1 × BR-2	-1.32 ± 0.82	-0.25 ± 0.3	2.24* ± 0.5	21.26
KJ-38 × SN445	2.5* ± 0.36	-0.06 ± 0.3	1.04 ± 0.7	31.52
KJ-38 × BR-2	2.09* ± 0.51	-0.07 ± 0.2	0.17 ± 0.6	19.36

Gene Effects

Crosses	m	d	h	i	j	L
PSB-1 × SN-445	2.31* ± 0.09	2.38* ± 0.21	1.10 ± 0.6	2.84* ± 0.5	0.49* ± 0.2	-4.72* ± 1.0
PSB-1 × BR-2	3.19* ± 0.13	1.53* ± 0.44	-5.03* ± 1.0	-3.83* ± 1.0	-0.54 ± 0.4	5.41* ± 1.8
KJ-38 × SN445	2.78* ± 0.17	2.18* ± 0.20	0.65 ± 0.8	1.07 ± 0.8	0.99* ± 0.2	-3.18* ± 1.1
KJ-38 × BR-2	2.12* ± 0.12	2.47* ± 0.22	0.91 ± 0.6	1.85* ± 0.6	1.09* ± 0.2	-3.88* ± 1.0

Values in parentheses are expected values

* Significant at 5% level

responsible for resistance have shown their superiority over those responsible for susceptibility which is in concurrence with the findings of Swarup *et al.* (1972) and Sharma et al. (1979). However, Williams *et al.* (1972) and Sharma *et al.* (1979). However Williams *et al.* (1972) and dickson and Hunter (1987) have reported resistance to be under the control of recessive genes in case of cabbage var 'Early Fuji'.

In F_2 s the mean disease index value (Table 1) was more than F_1 for every cross and none of the crosses gave mean value less than the resistant parent. The disease index was also less than the expected mean value. This further confirmed the dominance of the genes responsible for resistance over those for susceptibility. The disease reactions of the back cross progenies tended towards their recurrent parents. When recurrent parent was resistant, a reduction in disease index was noticed, thereby indicating additivity of the genes and vice versa with susceptible parent. Earlier Chatterjee and Swarup (1972) and Monakhos *et al.* (1990) have also reported resistance to be under the control of polygenes dominant with additive nature. The deviation of the mean disease index values from the expected means in F_2 and B_2 generations in every cross attempted, indicated the presence of some inter allelic interactions. These results are in line to those of Sharma et al. (1979) who also observed inclination of the disease index ratings towards the resistant parent in F_2 and back cross generations.

Significance of individual and joint scaling test in all the four crosses further confirmed the presence of inter allelic interactions (Table 1). All the crosses exhibited significant and positive additive (d) and dominant (h) gene effects with relatively higher magnitude of additive gene effects. Tewari *et al.* (1979) also reported significance of additive gene effects in cabbage while studying inheritance of resistance to black rot. The additive x additive (i) gene effects were also significant for all the crosses except the cross KJ-38 × SN-445. Tewari *et al.* (1979) have also reported the preponderance of the additive × additive gene effect in controlling the resistance to black rot. Barring PSB-1 × BR-2 none of the other cross combinations were able to show positive and significant dominance × dominance gene effects. This cross also gave negative dominance (h) gene effects, which indicated effect of duplicate genes involved in controlling the disease resistance. Williams *et al.* (1972) have also reported presence of duplicate interaction modifying the expression of the genes responsible for resistance against black rot in cabbage.

The present investigations revealed that the genotypes SN-445 and BR-2 carry the genes for resistance to black rot, which were quantitatively inherited and dominant in expression. In all the crosses attempted between susceptible and resistant parents additive gene effects were found to be opposite in direction to additive gene effects indicating the presence on inter allelic interactions. Therefore it is suggested that back cross breeding programme followed by intensive selection in segregating generations can lead to outcome of a resistant variety with good horticultural characters.

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GENE ACTION AND COMBINING ABILITY IN RELATION TO DEVELOPMENT OF HYBRIDS IN WHEAT

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ABSTRACT

A line x tester analysis for combining ability and gene action in wheat revealed that the GCA and SCA variances were significant for all the traits with preponderance of non-additive gene action and over dominance. The female parents C801, C771, C772, C795, and C453 and the male parent HUW206 were superior on the basis of per se performance and GCA effects. Superior specific cross combinations generally involved medium x medium and medium x low combiners i.e. C769/HUW234, C799/C243, C798/C244, C455/HUW206. Cross C436/C243 showed higher SCA effects for yield/plant. C438/C244, C769/C244, C769/C244, C769/HUW206, C773/HUW206 and C795/HUW234 were promising for 3 characters each on the basis of per se performance and sca effects. The utilization of good general combiners in the development and commercial exploitation of wheat by brids may be feasible.

Key words : Wheat, line x tester, gene action, combining ability.

The wheat productivity in frontline areas has reached to a saturation level. Development of hybrids through exploitation of heterosis may bring about a quantum jump in the productivity as well as in production of whet. Thus, the understanding of inheritance of various traits and the selection of genetically superior parents are important prerequisites. The combining ability analysis provides useful information on genetic worth of parents and their hybrids and lucidates the nature and magnitude of various types of gene action governing the quantitative traits. In the present investigation, line x tester analysis was used to obtain information on the nature of gene action and combining ability for yield and its component traits in wheat.

MATERIALS AND METHODS

Twenty-four genotypes of wheat [*Triticum aestivum* (L.) em. Thell] exhibiting wide ranges of variation for morphological and agronomic characters were selected. Out of these, four genotypes (C243, C244, HUW 206 and HUW 234) were crossed as testers with each of the other twenty genotypes used as lines. All the twenty-four parents and 80 F_1 hybrids were evaluated

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Table 1. Estimates of components of variance for 11 traits in wheat

Components	Days to 50% flowering	Days to maturity	Plant height	Number of productive tillers/plant	Spike length	Number of spikelets/ spike	Number of grains/ spike	Grain weight/ spike	100-seed weight	Yield/ plant	Harvest index
σ^2gca	0.07	0.59	15.56	0.03	0.30	0.32	3.12	0.01	0.06	0.61	2.02
σ^2sca	1.02	7.47	56.54	1.60	0.61	1.31	13.31	0.06	0.10	5.25	20.48
σ^2gca/σ^2sca	0.07	0.08	0.28	0.02	0.49	0.24	0.23	0.17	0.60	0.12	0.10
$(\sigma^2sca/\sigma^2gca)^{0.5}$	3.82	3.56	1.91	7.30	1.43	2.02	2.07	2.45	1.29	2.93	3.18

in randomized block design with three replications during rabi 1997-98. The parents were randomized among themselves as suggested by Arunachalam (1974). The plot size was double row of 3 m length with spacing of 25cm between the rows and 10cm between the plants. All the recommended agronomic practices were adopted for raising a good crop. The observations were recorded on ten randomly selected plants in each parent and F1s for eleven yield and component traits, viz, days to 50% flowering, days to maturity, plant height (cm), number of productive tillers/plant, spike length (cm), number of spike lets/spike, number of grains/spike, grain weight/spike (g) 100-seed weight (g), yield/plant (g) and harvest index (%). The combining ability analysis (Kempthorne, 1957) was done using SPAR programme.

RESULTS AND DISCUSSION

The estimates of variance component due to general combining ability (σ^2 gca) and specific combining ability (σ^2 sca) indicated the pre-dominance of non-additive gene action in the inheritance of all the traits (Srivastava et al., 1992; Senapati et al., 1994; Rajara and Mehashwari, 1996). In addition, the average degree of dominance is also of interest to plant breeders. In the present study, all the traits showed over dominance (Lonc and Zalewski, 1991; Prodanovic, 1993). As non-additive gene action is non-fixable, it would favour hybrids with greater magnitude of heterosis. However, the chances of exploiting heterosis in wheat at present are bleak due to its autogamous nature. Under such condition, the breeding method such as biparental mating followed by recurrent selection may result in faster rate of genetic improvement. Recurrent selection scheme has been proposed in wheat and barley (Byrne and Rasmusson, 1974) and it might be feasible if commercial exploitation of male sterility is adopted because making crosses is quite tedious in self pollinated crops.

Selection of suitable genotypes and their crosses for effective hybridization programme is a prerequisite in order to formulate a systematic breeding programme leading to rapid and sustained improvement. The combining ability analysis furnishes the information on these aspects. Estimates of GCA effects for different characters (Table 2) indicated that none of the parent was good general combiner for all the 11 characters. However, some genotypes were

Table 2. Estimates of general combining ability effects of parents for 11 yield traits in bread wheat

S. No.	Parent	Days to 50% flowering	Days to maturity	Plant height	Number of productive tillers/plant	Spike length	Number of spikelets/ spike	Number of grains/ spike	Grain weight spike	100-seed weight	Yield/ plant	Harvest index
	Tester											
1	C243	-0.24**	1.32**	-4.95**	0.29**	-0.42**	0.30**	1.27**	0.01	-0.07**	0.61**	-0.90**
2	C244	0.08	0.22**	-0.97**	0.30**	-0.32**	0.08**	-0.93**	-0.17**	-0.28**	-0.93**	-0.39**
3	JUW206	-0.29**	-0.93**	0.70**	-0.32**	-0.16**	-0.89**	-2.35	0.12**	0.86**	0.52**	2.60**
4	HUW234	0.51**	-0.61**	5.21**	-0.27**	0.90**	0.50**	2.01**	0.04**	-0.01**	-0.20**	-1.31**
	Line											
1	C436	-0.49**	0.35**	-2.13**	-0.35**	-1.08**	0.58**	1.31**	-0.19**	-0.34**	-2.11**	-2.99**
2	C438	0.09	3.52**	1.10**	-0.54**	0.28**	-0.30**	-0.09	0.24**	0.42**	0.91**	-3.65**
3	C453	-0.49**	1.35**	-6.31**	-1.57**	-0.56**	0.57**	1.77**	0.10**	0.01*	-2.91**	2.22**
4	C455	0.09	0.02	0.17	-0.65**	-0.04	1.16**	3.34**	0.06**	-0.17**	-0.51**	-1.49**
5	C769	-0.07	-0.15	-9.17**	0.47**	0.10*	-0.83**	-1.93**	-0.41**	-0.29**	-3.45**	-2.10**
6	C770	-0.24**	-0.73**	-12.12**	-0.09**	-0.14**	-0.50**	-2.16**	0.08**	0.08**	0.86**	3.69**
7	C771	-0.99**	-0.06	-0.98**	0.26**	0.26**	0.83**	1.86**	0.10**	0.15**	1.04**	-3.38**
8	C772	0.84**	1.60**	6.46**	-0.53**	-0.03	0.41**	0.50**	0.36**	0.33**	1.83**	3.14**
9	C773	0.34**	1.02**	1.22**	0.63**	0.09*	0.40**	1.10**	0.04**	0.05**	1.90**	1.81**
10	C778	1.01**	0.35**	-2.13**	1.54**	-0.18**	0.97**	3.04**	-0.01	-0.14**	3.71**	3.08**
11	C795	0.51**	0.1	8.07**	0.50**	0.19**	0.22**	0.26**	0.11**	0.22**	1.85**	-0.87**
12	C798	-0.07	-1.40**	13.47**	-0.15**	0.71**	-0.32**	0.04	0.19**	0.41**	1.67**	0.99**
13	C799	-0.32**	0.60**	-2.20**	-0.44**	0.02	-0.03	0.45**	-0.03**	-0.13**	-1.02**	-0.71**
14	C801	0.68**	-0.90**	4.31**	-0.01	0.85**	0.44**	1.36**	0.10**	0.19**	1.17**	4.06**
15	CPAN1990	-0.57**	-1.06**	-0.41**	-0.05	-0.16**	-1.28**	-2.98**	-0.31**	-0.39**	-2.81**	-1.83**
16	Galvez87	-0.91**	1.69**	3.35**	0.77**	0.64**	0.73**	-2.07**	-0.16**	-0.30**	-0.07	2.10**
17	Raj3077	-0.16	-0.40**	0.63**	0.30**	-0.74**	-1.12**	-4.45**	-0.18**	-0.05**	-0.53**	-0.04
18	UP2338	0.76**	-2.06**	-0.92**	0.45**	-0.29**	-0.59**	-2.08**	0.01	0.09**	1.06**	-2.79**
19	WL711	0.01	-3.56**	1.87**	-0.40**	0.62**	0.47**	1.31**	0.11**	-0.10**	-0.34**	1.75**
20	WL6975	0.01	-0.31**	-4.29**	-0.22**	-0.53**	-1.84**	-4.72**	-0.20**	-0.04**	-2.23**	-2.98**
	S.E.$(g_i)\pm$	-0.05	0.04	0.05	0.02	0.02	0.02	0.02	0.01	0.03	0.05	0.03
	S.E.$(g_j)\pm$	0.12	0.11	0.13	0.04	0.04	0.06	0.06	0.01	0.01	0.12	0.06
	S.E.$(g_i-g_i')\pm$	0.09	0.08	0.09	0.02	0.03	0.04	0.04	0.01	0.01	0.09	0.05
	S.E.$(g_j-g_j)\pm$	0.19	0.18	0.21	0.07	0.07	0.07	0.09	0.02	0.01	0.19	0.11

* ** significant at 5% and 1% levels respectively

identified for their superiority with respect to yield and its components. On the basis of GCA effects, C771 for days to 50% flowering, WL711 for day to maturity, C770 for plant height, C778 for number of productive tillers/plant and yield/plant, C801 for spike length, C455 for number of spikelets/spike and number of grains/spike, C772 for grain weight/spike, C438 for 100-seed weight and C799 for harvest index were significantly superior combiners among females. HUW 206 among male parents was superior combiner for most of the traits including yield/plant. In general, GCA effects showed that it was difficult to pick out good combiners for ll the traits together due to the negative association among some traits. Among female parents, C778, C773, C795, C772, C798 and C801 were good general combiner for yield/plant. For more critical assessment, the parents were ranked first on the basis of per se performance and then on the basis of their GCA effect for all the traits. According to rank index, C801 was best general combiner as it had better performance for spike length, number of grains/spike, grain weight/spike and 100-seed weight followed by C771, C772 and C795 among females. Among males, HUW 206 was best combiner for six traits on rank index basis. The additive parental effects as measured by GCA effects are of practical use to plant breeder, since non-allelic interactions are unpredictable. As aforesaid parents having good GCA effects are superior for many traits, a population improvement programma or exploitation of heterosis by developing hybrids may be expected to offer the maximum promise. Selection for economic traits in such a population is likely to provide worthwhile gain for yield potential. The good general combiners for yield/plant also had significant gca effects in desirable direction for some of the yield contributing traits, more often, grain weight/spike and 100-seed weight. Thus, these traits appear to be a valuable component for yield in wheat.

The cross combinations C798/C243 for days to maturity, C769/C243 for plant height and number of productive tillers/plant; C769/C244 for spike length, number of spike lets/spike and grains/spike, UP2338/C243 for grain weight/spike, C769/WUW206 for harvest index were superior in terms of specific combining ability. C799/C243, C798/C244, C455/HUW206 and C436/C243 were also good combinations for yield/plant. Although a considerable number of crosses, had desirable SCA effects, but on the basis of per se performance and SCA effects, it was noted that the crosses were not exactly in the same order of ranking (Table 3). This indicated that the choice of best cross combination on the basis of high SCA effects could not necessarily be the one that could be based on per se performance. A critical observation of the results with respect to SCA effects showed that only one cross C799/C243 exhibited consistently high desirable SCA effects for all the traits. None of the crosses were found superior for all the characters on the basis of per se performance and SCA effects.

Cross C769/HUW 234 having highest SCA value for yield/plant also showed \highly significant SCA values for number of productive tillers/plant, spike length, number of spikelets/spike, number of grains/spike,

Table 3. Frequency and ranking of desirable crosses based on per se performance and SCA effects for 11 characters in wheat

S.No.	Character	Frequency	Best cross combinations on the basis of		GCA effects of the parents	Common crosses
			Per se performance	SCA effects		
1	Days to 50% flowering	24	C798/C243	C798/C243	MXM	C798/C243
			C438/C244	C438/C244	LXM	C438/C244
			C771/HUW206	C769/HUW206	MXH	C436/C244
			C436/C244	Galvez87/HUW234	HXL	
			C453/C243	C436/C244	HXL	
2	Days to maturity	37	WL711/HUW206	C438/HUW234	LXH	C769/HUW206
			UP2338/HUW206	C770/C243	HXL	
			C769/HUW206	C801/C243	HXL	
			C798/HUW206	C436/C243	LXL	
			WL711/C244	C769/HUW206	MXH	
3	Plant height	36	C769/C243	C769/C243	HXH	C769/C243
			C770/C243	C798/C243	LXH	C453/HUW 206
			C453/HUW206	Galvez87/HUW234	LXL	
			C770/C244	C773/HUW206	LXL	
			WL6975/C243	C453/HUW206	HXL	
4	Number of productive tillers/plant	40	C769/C243	C769/C243	MXM	C769/C243
			UP2338/HUW206	UP2338/HUW206	MXL	C771/C244
			C771/C244	C771/C244	MXM	UP2338/HUW206
			C778/C243	C772/C243	LXM	
			C795/C244	WL711/C244	LXM	
5	Spike length	37	C798/HUW234	C769/C244	MXL	
			C769/HUW234	C773/C244	MXL	
			C799/HUW234	CPAN1990/HUW206	LXL	
			C771/HUW234	C455/C243	LXL	
			C795/HUW234	C778/C243	LXL	
6	Number of Spike-lets /spike	29	C795/HUW234	C769/C244	LXM	C795/HUW234
			C455/HUW234	C795/HUW234	MXH	C769/C244
			C769/C244	C436/C244	HXM	C436/C244
			C773/HUW234	Galvez87/HUW206	HXL	
			C436/C244	C773/HUW234	MXH	C773/HUW234

S.No.	Character	Frequency	Best cross combinations on the basis of		GCA effects of the parents	Common crosses
			Per se performance	SCA effects		
7	Number of grains/spike	36	C795/HUW234	C769/C244	LXL	C795/HUW234
			C436/C244	C436/C244	HXL	C436/C244
			C769/C244	C795/HUW234	MXH	C769/C244
			C773/HUW234	Galvez87/HUW206	LXL	
			C455/HUW234	C801/HUW206	HXL	
8	Grain weight spike	35	C438/HUW206	UP2338/C243	MXM	UP2338/C243
			C772/HUW234	C769/C244	LXL	C772/C244
			UP2338/C243	C772/C244	HXL	
			C772/C244	C778/C244	LXL	
			C772/HUW206	C798/C244	HXL	
9	100-seed weight	41	C438/HUW206	C769/HUW234	LXL	-
			C798/HUW206	C798/C244	HXL	
			C771/HUW206	WL711/HUW234	LXL	
			C772/HUW234	C455/HUW206	LXH	
			C773/HUW206	795/C243	MXL	
10	Yield/plant	23	C771/C243	C769/HUW234	LXL	C798/C244
			C798/C244	C799/C243	LXM	UP2338/HUW206
			C778/HUW206	C798/C244	MXL	
			C778/C243	C455/HUW206	LXM	
			UP2338/HUW206	C436/C243	LXM	
11	Harvest index	32	C772/HUW206	C772/HUW206	HXH	C772/HUW206
			C770/HUW206	C770/HUW206	HXH	C770/HUW206
			C773/HUW206	C773/HUW206	MXH	C773/HUW206
			C436/HUW206	C436/HUW206	LXH	C436/HUW206
			C771/HUW234	C771/HUW234	LXL	C771/HUW234

H, M and L are good, average and poor general combiner, respectively.

grain weight/spike and harvest index. Ten crosses showing maximum SCA values for yield/plant were C769/HUW234, C799/C243, C798/C244, C455/HUW206, C436/C243, WL6975/HUW206, C771/C243, C438/HUW234, C770/HUW234 and UP2338/HUW206. These cross combination also had significant SCA values for other traits in desirable direction.

The good specific combiners for yield/plant involved all the possible combinations between the parents possessing high and low GCA effects viz., high × high; high × medium, high × low, medium, medium × low and low × low. In the crosses showing maximum SCA values for yield/plant, most of the crosses had medium × medium (C771/C243 and UP2338/HUW206) and medium × low (C799/C243, C798/C244, C455/Huw 206, C436/C243, WL 6975/HUW206, C438/HUW234 and C770/HUW 234) combinations. On the showing maximum SCA values for yield/plants had low × low, medium × medium and medium × high combinations also indicated the non-additive gene action. Similar tend was also observed for other characters. From the above findings, it is obvious that the best cross combinations are not always obtained between high × high but may also occur in low × low combination.,

From the foregoing, it is concluded that the non-additive gene action was predominant for all the traits studied with over dominance nature. Parents C801, C771, C772, C795, C453 and UP2338 among females and HUW206 among males were good combiners for three or more traits. These may be used in hybrid development programme as parents. The cross combinations C769/HUW234, C799/C243, C798/C244, C771/C243 and C455/HUW206 have desirable SCA effects for yield/plant thus, these may be commercially exploited for higher productivity.

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GENETIC DIVERGENCE STUDIES IN SALINITY TOLERANT WHEAT GERMPLASM USING CLUSTER ANALYSIS

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ABSTRACT

The nature and magnitude of genetic deversity was assessed using non-hierarchical Euclidean cluster analysis in 139 salinity tolerant breeding lines/germplasn of bread wheat (*T. aestivum* L. *em.* Thell) for grain yield and its contributing characters. All the genotypes were influenced by the source and origin. In general, the major cluster in the divergence analysis had the genotypes of heterogeneous erigin in the same cluster which showed that there was n parallelisn between genetic and geographic diversity. The member of cluster 1 and 4 were highly diverse from each other. Cluster 4 had mean value for grain yield per plant, and other characters. Genotypes were also identified which may serve as potent genetic donors for some metric traits.

Key words : *Triticum aestivum*, non-hierarchical euclidean cluster analysis, genetic divergence, salinity tolerance.

Reduction in genetic variation of cultivated wheat makes it increasingly vulnerable to biotic as well as abiotic factors like salinity tolerant [3]. Mahalanobis D^2 statistic desired by Rao [7] has been utilized by a number of workers for estimating genetic divergence. Although D2 statistic has been widely used as a quantitative measures of genetic divergence, yet the clustering pattern of the genotypes is arbitrary [9]. In the present study, salinity tolerant genotypes were subjected to non-hierachical Educlidean cluster analysis to over come the limitation of D^2 statistics. Precise information on the nature and degree of genetic diversity present in wheat collections from its principal area of cultivation could help to select parents for evolving superior wheat varieties aimed at developing salinity tolerant wheat varieties.

MATERIALS AND METHODS

The experimental materia comprosed 139 variable salinity tolerant genotypes of wheat germplasm maintained in the Department of Plant Physiology, S.K.N. College of Agriculture, Jobner, Jaipur (Raj.). All the germplasm accessions were planted in an augmented design during *rabi* 1998-99 in Salinity Nursery, Research Farm Department of Plant Physiology. Each genotypes was assigned to paired rows of 2 meter long plot with 30 cm row to row distance. The checks namely, HD 4530, Karchia 65 and KRL 1-4 were allotted randomly in the blocks. All the recommended cultural and management practices were followed to raise a good crop. The data were then recorded on ten yield and its contributing quantitative characters on per plant basis. To study genetic diversity, the data were analyzed using non-hierarchical euclidean cluster analysis [10].

RESULTS AND DISCUSSION

The analysis of variance showed that the checks varieties differed significantly for all the characters showing thereby genetic differences between the check varieties. Block effects were in general nonsignificant for all the characters except days to maturity and 50-grains weight indicating bomogeneity among the blocks. General mean, range, variance and coefficient of variation different characters is presented (Table 1). Maximum value of coefficient of variability was observed in number of tillers per unit area followed by grain yield per plant, biological yield and yield per ear indicating higher contribution of these characters towards genetic divergence. The variability was observed to be moderate for plant height, Spikelets per ear, number of grain per ear and harvest index. However, maximum variance was obtained in plant height.

The clustering pattern of the genotypes presented (Table 2) revealed that all the genotypes were grouped in 10 cluster. The maximum number of genotypes (24) were present in cluster 7 and minimum number of genotypes (6) were present in cluster 6. Cluster mean showed appreciable differences for all the characters, particularly in cluster 6. Cluster mean showed appreciable differences for all the characters, particularly in plant height, number of tillers per unit, number of grains per ear, biological yield per plant. Cluster 4 had high mean value for number of tiller per unit area (39.70), Spikelets pe ear (20.13), number of grains pre ear (60.40), yield per ear (2.83 g), biological yield (25.38g) and grain yield per plant (10.97). Cluster 7 having highest days to maturity (137.33) and cluster 6 had the genotypes having highest test height (27.39 g). Cluster 5 and 7 were quie close with respect to means of most of the characters. Clusters 1 had highest coefficient of curability for plant height and days to maturity. Cluster 6 had highest CV for number of grain per ear and 500 grains weight while cluster 3 had highest CV for grain yield per plant and cluster 4 had highest CV for harvest index. Cluster 7 had highest CV for Spikelets per ear and cluster 5 had highest CV for number of grain per ear.

This suggest the that grain yield per and tillers per unit area serve as potent characters for genetic divergence. The yielding of the material, in general was found to be coupled with high value number of tillers per unit area, yield per ear and biological yield. Therefore, it is suggested that a crossing programme involving parent material selected for the total divergence, based upon grain yield per unit area, yield per ear and biological yield. Therefore, it is suggested that a crossing programme involving parent material selected for the total divergence, based upon grain yield per plant, tillers per unit area, per ear and biological yield might lead to an over all improvement in yield.

The major cluster contained genotypes of heterogeneous origin. Therefore, there was no parallelism between genetic and geographic diversity. These findings are agreements with the results obtained by Singh & Bains (1986), Bhatt (1970), Garg and Gautam (1988) and Patil & Bhavasar (1997).

Intra cluster and inter cluster distances are presented (Table 3). The magnitude of intra cluster distance measures the extent of genetic diversity between the cultivar of same cluster. Inter cluster distance is measuring of genetic distance between two clusters. The intra cluster distance was maximum (2.455) in cluster 6 and minimum (1.812) in cluster 9. The maximum inter cluster distance (6.996) was observed between cluster 1 and 4, and minimum inter cluster distance (1.904) was present between cluster 7 and 9. The clustering pattern of germplasm in the present study was not distinctly influenced by the source and origin. These results are similar to those reported by Yadav *et al* (1974). Table 3

Table 1. General mean, range, varience and C.V. for different characters of wheat

S.No.	Characters	General mean	Range	Variance	C.V. (%)
1	Plant height	79.20	53.39-123.32	148.84	25.40
2	No. of tillers/unit area	26.07	8.08-56.71	89.49	15.40
3	Spikelets/ear	15.83	10.70-23.83	5.81	15.22
4	No. of grain/ear	47.02	28.23-66.23	48.16	14.76
5	Yield/ear	2.07	1.15-3.17	0.14	17.87
6	Days to maturity	135.95	132.55-140-89	2.62	1.19
7	500-grain weight	22.03	15.21-30.81	6.40	11.48
8	Biological yield	18.30	8.17-29.30	19.80	24.32
9	Harvest index	39.40	28.30-51.90	27.98	13.43
10	Grain yield/plant	7.28	2.86-13.20	5.34	31.73

Table 2. Inter and intra cluster distance among ten clusters of salinity tolerant germplasm

Cluster	1	2	3	4	5	6	7	8	9	10
1	(20.025)	(3.506)	2.724	6.996	1.991	5.625	3.120	4.401	2.078	4.284
2		(1.898)	3.518	4.477	3.384	3.396	3.483	3.544	3.088	2.412
3			(2.030)	5.241	3.253	5.165	2.015	3.199	2.157	3.214
4				(2.239)	6.850	4.267	5.138	3.807	5.530	3.243
5					(1.922)	4.613	2.721	4.417	2.344	4.457
6						(2.455)	3.876	4.076	4.335	3.757
7							(1.896)	2.828	1.904	3.318
8								(2.137)	3.329	3.120
9									(1.812)	3.047
10										(2.038)

*Value in parenthesis are intra cluster distance.

indicated the estimates of inter and intra cluster distances in the present materials. These provide index of genetic diversity among and within the cluster. It showed be logical to attempt the cross between the genotypes of cluster separated by large estimated inter cluster distances. Cluster 1 contained 15 genotypes viz. NW 1056, K 9107, KAZ 9683, DL 975-1, NW 1074, NW 1081, NW 1082, NW 1997 (S) 2, KRL 1006, KRL 1007, KRL 1008, Job 69, PS 464, K 972. Cluster 4 contained 8 genotypes viz. Job 666, Job 673, WH 636, Raj 3850 DL 788-2, NW 1036, NW 1046, KYZ 9703. The cluster 1 and 4 having maximum inter cluster distance showed that their members were for apart from each other and it would be useful to attempt crosses among them. The cluster 7 and 9 having minimum cluster distance showed that heir members were quite close and due to be taken while attempting crosses among members of the clusters. It was observed that the relative contribution of yield *per se* and tillers per

Table 3. Genotypes identified for different characters from the salinity tolerant wheat germplasm used

Characters	No. of	Name of germplasm genotypes
High yield	15	Job 66,Job 673, KRL 38, KNS 75, DL 770-2 NW (S), NW (S) 95-5, WH 636, DL 788-2, K 9353, MPJ 12, NW 1036, NW 1045, KRL 1002, Job 828.
Bold grain	31	KNS 75, DL 788-2, Job 151, DL 1107-3, DL 1192-1, H-1161-3-6, H-1161-14-2, H-1161-3-2, WR 734, WR 815, WR 820, WR 824, WR 846, K 9351, K 9351, K 9507, K 9545, K 9546, K 9709, KYZ 9701, KYZ 9702, KYZ 9705, NW 1997 (S) 4, KRL 1002, KRI 1003, KRL 1010, Job 99.
High spikelets fertility	38	KRL 3-4, Job 666,Job 673, KNS 58, KNS 75, DL 770-2, NW (S) 95-5, WH 643, WH 636, Raj 3850, Raj 3890, DL 788-2, NW (S) 95-13, NW 1036, NW 1045, H-1161-3-6, H 1159-32-2, H-1161-3-2, WR 734, WR 740, WR 811, WR 813, WR 814, WR 815, WR 824, K 9351, K 9465, K9709, KYZ 9701, KYZ 9703, KRL 1004, WH 700, WH 701
High tillering capacity	28	KRL 3-4, KRL 13, Job 666, 73, KRL 4-6, KRL 38, KNS 57, KNS 58, KNS 75, DL 770-2, NW (s) 94-20, NW (S) 95-5, WH 643, Raj 3890, DL 788-2, K 9353, MPJ 12, AKW 1071, NW(S) 95-13, KRL 22, NW 1036, MW 1045, WR 734, Job 79, Job 146, Job 2028
High harvest index(%)	21	Job 66, NW(S) 95-5, NW (S) 95-13, K 9006, NW 1032, Job 64, Job 73, Job 134, Job 151, UP 2338, KRL 1002, KRL 1003, KRL 1004, KRL 1007, KRL 1009, KRL 1010, Job 75, Job 828, Job 983, Job 2028, UP 2458.

unit are to wards genetic divergence was very high. Which confirms the previous results with Jaina and Aulakh (1971), Randhawa *et al* (1975), and Patil and Bhavasar (1997).

A perusal of table 4 showed that he genotypes namely, Job 666, KNS 75, NW (S) 95-5 and DL 788-2 were found to be superior for all the selected attributed like high yield, bold grain, high Spikelets fertility, high tillering capacity and high harvest index. Therefore, these might serve as useful resources for further breeding programme aimed at developing salinity tolerant varieties.

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GENETIC VARIABILITY AND CORRELATION STUDIES IN GINGER *(ZINGIBER OFFICINALE* ROSC.)

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ABSTRACT

Twenty-four genotypes of ginger were evaluated for ten morphological and yield characters. These genotypes have showed considerable variability for all the parameters. Wide range of GCV and PCV were observed for chlorophyall content, rhizome breath, leaf length and leaf breadth. The heritability estimates were ranging between 40.31% for no. of fillers per plant to 86.96% for pseudostem length, these were accompanied by moderate genetic advance and genetic gain. Genotypic correlation coefficients were higher than corresponding phenotypic one for most of the character combinations. The rhizome yield per plant and yield per plot had significant and positive phenotypic correlation with number of leaves per shoot, number of tillers per plant, leaf length, lead breath, rhizome length and rhizome breath. It indicated that these traits are amenable to selection.

Key words : *Ginger, genetic variability, correlation.*

The success of phenotypic selection depends upon the range of genetic diversity available in the population for important economic characters and their inter-relationship. Ginger being an asexually propagated crop, the creation of genetic variability is the difficult process, most of the improvement work is based on the selection from existing variability. An attempt was made to assess the nature and extent of genetic variability for important traits, association among themselves and their relative contribution to yield in a collection of twenty-four genotypes of ginger (*Zingiber officinale* Rosc.). This information will be of great help, while selecting genotypes (s) suitable for growing in the low and mid hill region of the state.

MATERIALS AND METHODS

The experiment was conducted at the research farm Department of Vegetable Crops, Solan (Himachal Pradesh) during 1997-98 with twenty-four diverse genotypes in randomized blocks design. The rhizomes of 25-30 g each was planted in a plot of 3x1 m size with a spacing of 30 x 20 cm between and within rows, respectively. Then plants were randomly selected and tagged in each plot and observed for pseudostem length, number of tillers per plant, number of leaves per shoot, leaf length, leaf breadth, rhizome length, rhizome breadth, chlorophyll content, yield per plant and per plot. The mean values for each character were analyzed as per Gomez and

Gomez (1976).

Chlorophyll content was estimated by using DMSO as extracting agent as per the procedure given by Hiscox and Israelstan (1979). The variance components and coefficient of variation were computed as per Burton (1952). The heritability in broad sense and expected genetic advance were determined following Johnson *et al* (1995). The correlation coefficients were calculated according to milter *et al* (1985).

RESULTS AND DISCUSSION

Variability, heritability and genetic advance

The estimates of variability parameters viz., range coefficients of variation (GCV and PCV), heritability (broad sense), genetic advance and genetic gain were worked out and presented in Table 1. A rough estimate of degree of variation can be made form the range but the coefficients of variation are more reliable. In general phenotypic coefficients of variability were more than the genotypic coefficients of variability. Though the narrow range of GCV and PCV was observed for almost all the characters in the present study except for chlorophyll content (11 63 and 14.4%), rhizome breadth (1.08 and 14.04%), leaf breadth (11.19 and 13.44%) and leaf length (10.44 and 11.84%) in which it was comparatively winder, it indicated that these characters are amenable to selection. A wide range of variation for leaf length, leaf breadth and rhizome breadth were reported by Mohanty and Sarma (1979), Maity *et al*, (1989) and Sasikumar *et al* (1992).

The maximum estimates of genotypic coefficients of variability of these characters were further supported by high estimates of high estimates of heritability ranging between 40.31% for no. of tillers per plant to 86.96% for pseudostem length and moderate value of genetic advance. Burton (1952) suggested that GCV together selection while Johnson *et al* (1995) reported that high heritability and high genetic advance be given due consideration. In the present investigations the characters like leaf length, leaf breadth, rhizome breadth and chlorophyll content gave comparatively high estimates of genotypic coefficient of variability, heritability and genetic indicating the possibilities of bringing improvement in these characters. High estimates of heritability and genetic advance for leaf length, leaf breadth and rhizome breadth were also reported by Mohantya and Sarma (1979) and Maity *et al.* (1989).

Phenotypic and genotypic correlations

The phenotypic and genotypic correlations in all possible combinations among all the characters under present study are presented in Table 2. In the present study, the genotypic correlation coefficients were higher than phenotypic ones for almost all the characters, thus indicating that the environmental effects had not played mush role in reducing their actual association an the genotypic expression has bee truly expressed in the phenotypes. The rhizome yield per plant and yield per plot had significant and positive phenotypic correlation with number of leaves per shoot ().413 and 0.615), number of tillers per plant (0.632 and 0.679), leaf length (0.778 and 0.878), leaf breadth (0.801 and 0.97), rhizome length (0.739 and 0.578) and rhizome breadth (0.713 and 0.613). Similar results were also reported by Mohanty and SHARMA (1979),

Table 1. Range, mean, phenotypic and genotypic coefficients of variation, heritability in broad sense and genetic advance for quantitative characters in ginger

Characters	Range	Mean±SE(d)	PCV (%)	GCV (%)	Heritability (%)	GA	GA as per cent of mean
Pseudostem length (cm)	69.85-89.45	79.43±1.75	5.68	6.10	86.96	8,68	10.92
No of tillers/plant	6.10-9.03	7.07±0.65	7.59	11.95	40.31	0.70	9.92
No. of leaves/shoot	18.9023.45	20.92±0.86	4.81	6.32	57.92	1.57	7.53
Leaf length (cm)	16.55-25.35	20.59±1.15	10.44	11.84	77.83	3.91	18.98
Leaf breadth (cm)	2.08.3.23	2.54±0.19	11.19	13.34	69.36	0.48	19.21
Rhizome length (cm)	11.54-17.30	14.85±0.70	7.95	9.24	74.05	2.09	14.09
Rhizome breadth (cm)	4.38-7.14	5.43±0.47	11.08	14.01	62.29	0.97	18.02
Chlorophyll content (mg/g)	0.70-1.152	0.90±0.08	11.63	14.49	64.38	0.17	19.22
Yield/plot (kg.)	5.62-9.00	7.04±0.68	9.76	13.69	50.75	1.00	14.32
Rhizome yield/plant (g)	159.25-232.75	191.35±8.25	7.68	8.80	76.06	26.41	13.8

Table 2. Genotypic and phenotypic correlation coefficients among yield contributing characters in ginger

Characters		1	2	3	4	5	6	7	8	9	10
Pseudostem	rg	1.000	0.421	0.953	0.454	0.570	0.241	0.108	-0.108	0.555	0.2999
length (cm)	rp	1.000	0.441*	0.931**	0.499	0612**	0.282	0.173	-0.185	0.598**	0.380
No. of	rg		1.000	0.290	0.579	0.657	0.594	0.543	0.530	0.680	0.604
tillers plant	rp		1.000	0.443*	0.587**	0.683	0.481*	0.375	0.392	0.679**	0.632**
No of leaves/	rg			1.000	0.427	0.521	0.258	0.221	0.126	0.459	0.342
shoot	rp			1.00	0.487*	0.620*	0.318	0.263	0.215	0.615**	0.413*
Leaf length	rg				1.000	0.991	0.722	0.831	0.302	0.979	0.836
(cm)	rp				1.000	0.885**	0.581**	0.574**	0.264	0.878**	0.778
Leaf breadth	rg					1.000	0.667	0.766	0.264	0.931	0.791
(cm)	rp					1.000	0.600**	0.624**	0.314	0.967**	0.801**
Rhizome length	rg						1000	0.603	0.301	0.661	0.810
(cm)	rp						1.000	0.539*	0.277	0.578**	0.739**
Rhizome	rg							1.000	2.296	0.834	0.894
breadth (cm)	rg							1.000	0.133	0.613**	0.713**
Chlorophyll	rg								1.000	0.219	0.348
content (mg/g)	rp								1.000	0.298	0.395
Yield / plot	rg									1.000	0.827
(kg.)	rp									1.000	0.802**
Rhizome yield/	rg										-
	rp										-

Significant at * P=0.05, ** P=0.01

Sreekumar *et al.*, (1980), Rattan *et al.*, (1998), Maity *et al.*, (1989), Saikia and Shadeque (1992) and Sasikumar *et al.*, (1992).

Among other important traits, significant and positive associates were observed for pseudostem length with number of tillers per plant, number of leaves per shoot and leaf breadth, number of tillers per plant with leaf length, leaf breadth and rhizome length, leaf length with leaf breadth and rhizome length. It clearly indicated that these are important yield components of ginger and also ther is every possibility for simultaneous improvement of there traits through selection.

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CHARACTERIZATION OF THERMAL TIME REQUIREMENT OF FIVE WHEAT CULTIVARS UNDER VARIED WEATHER CONDITIONS

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ABSTRACT

Based on the field experiments carried out on the wheat crop for two *rabi* crop seasons on the silty clay loam soil of the I.A.R.I. Research Farm area, with an aim to characterize the thermal time requirement in different cultivars, it was inferred that even though thermal indices characterize the occurrence of phenological events in plants, variations do occur in the magnitude of the indices depending upon weather conditions. Magnitude of all the thermal indices were found to be lower in the second season as compared to those in the first season, which could be mainly attributed to the prevalence of higher temperature conditions in the former case. The other notable point was that even though the variation between the indices of the two seasons were relatively higher at initial stages, it declined gradually towards maturity. The reduction in the crop growth period in the second season resulted in lower heat use efficiency as well as the grain yield..

Key words : Degree-days, thermal time, weather, wheat.

Heat is essentially required for continuation of basic physiological processes in all the living beings. In case of plants, each species requires certain amount of accumulated heat to shift over to next phenological stage, which is a characteristic of that species or variety. This phenomenon was realized long back in the 18th Century by Reaumur (1735), who noted that accumulation of daily shade temperature of air between one stage of development and another was constant for a particular species. Bossingault (1834) calculated the total quantity of heat required to ripen the grain using this approach. However, studies have shown that variations occur in the magnitude of the indices depending upon weather conditions. Based on exhaustive field experiments, Chakravarty and Sastry (1983) postulated that the thermal indices could be better indices than any other index to quantify the crop-weather interactions in different varieties of wheat. Strand (1987) reported that early sowing in wheat increased the heat sum requirement by the cultivars. Bishnoi and Taneja (1990) showed that with the increase of average temperature in the crop season, phenological stages appeared rapidly due to availability of higher thermal

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units over a short period of time. Ghadekar *et al.* (1992) reported that early sowing which allowed for the highest accumulation of heat sum and photo thermal units resulted in better growth and yield of the crops. This means, it is necessary to analyze to what extent thermal indices vary in different weather conditions. This type of study particularly assumes importance in the present context where wide fluctuations of year-to-year weather conditions are witnessed because of global climate change. Keeping this in view, a study was planned with wheat crop grown in two consecutive seasons.

MATERIALS AND METHODS

Two field experiments were carried out during *rabi* seasons of 1998-1999 and 1999-2000 in the silty clay loam soil of IARI Research Farm with five cultivars of wheat viz., HD-2285, HD-2329, PBW-175, PBW-343 and C-306. The experiments were carried out in plots of 5×4 m^2 size with four replications in a randomized block design and with a row-to-row spacing of 22.5 cm. Crop management practices were carried out as per recommended agronomic practices. In order to get appreciable differences in the exposure conditions, the dates of sowing were made to be different in the two seasons (26th November and 16th December, for the 1998-99 and 1999-2000 crop seasons, respectively). The daily meteorological observations viz., maximum temperature, minimum temperature and bright sunshine hours recorded at the meteorological observatory of IARI (located about 300 m south of the experimental field) during the crop growth period were used for the study. Based on observations at 3-4 days interval, occurrence of difference phenological events viz., emergence, tillering, boot leaf, ear emergence, anthesis and hard dough were demarcated. When 50% of the plants in a plot reached a particular event, that day was considered to denote that event.

From the crop and weather related data, different thermal indices viz., growing degree days (GDD), helio thermal units (HTU), photo thermal units (PTU) and heat use efficiency (HUE) were computed for the five cultivars in both the seasons. The GDD was calculated by cumulating the departure of mean daily temperatures from the base temperature (Nuttonson, 1955), which can be mathematically expressed as :

$$\text{GDD } (^0\text{days}) \overset{n}{\underset{i=1}{=}} \sum T_{mean} - T_{base}$$

Where,

T_{mean} = Mean daily temperature in ^{0}C

T_{base} = Base temperature in ^{0}C (For wheat, it was taken to be 5^0C)

n = Number of days during which the heat units were accumulated

Heliothermal units (HTU) and photo thermal units (PTU) were computed by multiplying the GDD with actual bright sunshine hour and maximum possible sunshine hour values, respectively, whereas the heat use efficiency (HUE) was calculated by dividing the biomass with the GDD accumulated i.e.,

Table 1. Growing degree days taken to reach different phenological events (from sowing) in the five wheat varieties during 1998-99(I) and 1999-2000(II) crop seasons

Stages	HD2285		HD2329		PBW175		PBW343		C306		C.V.%
	I	II	I	II	I	II	I	II	I	II	-
Crown root initiation	251	180	251	191	275	191	263	199	270	191	17.1
Tillering	468	326	474	326	474	316	474	377	486	326	18.82
Bootleaf	710	622	738	652	791	722	791	722	776	692	7.81
Ear emergence	832	722	832	722	909	796	909	839	909	767	8.76
Anthesis	909	796	947	839	947	903	998	1074	1016	873	9.06
Hard dough	1395	1389	1485	1389	1508	1434	1663	1610	1616	1557	6.84

$$\text{HUE (gm/m}^2\text{/}^0\text{ day)} = \frac{\text{Biomass (gm/m}^2\text{)}}{\text{GDD (}^0\text{days)}}$$

RESULTS AND DISCUSSION

The GDD taken to reach different phenological events (from sowing) in the five cultivars during both seasons are presented in Table 1. In the first crop season, GDD requirement for CRI, anthesis and hard dough stages varied from 251, 909 and 1395 ^{0}days in the variety HD-2285 to 270, 1016 and 1616 ^{0}days in the variety C-306. The corresponding values for the second season were lower with relatively lower coefficients of variation (C.V.) of 17.10, 9.06 and 6.84%. This lower GDD requirement in 1999-2000 crop season in all the cultivars and all the growth stages is attributed to lower crop growth duration in this season. However, the difference upto CRI stage in the GDD taken was due to prevalence of very low temperature conditions in the first four weeks of this season. Such observations of lower values of GDD due to reduction in crop growth period have earlier been reported by Strand (1987), Ghadekar et.al.(1992), Rao *et al.* (1992), Agrawal *et. al.* (1999) and Sandhu *et. al.* (1999).

The variation in the HTU requirement in the two seasons was higher (Table 2) for all varieties at all stages of crop growth as

Table 2. Heliothermal units taken to reach different phenological events (from sowing) in the five wheat varieties during 1998-99(I) and 1999-2000(II) crop seasons

Stages	HD2285		HD2329		PBW175		PBW343		C306		C.V.%
	I	II	I	II	I	II	I	II	I	II	-
Crown root initiation	1619	459	1619	459	1637	459	1629	459	1629	459	59.01
Tillering	2134	1159	2155	1159	2155	1118	2155	1351	2193	1159	30.74
Bootleaf	3352	2809	3603	3106	3926	3568	3926	3568	3815	3425	10.14
Ear emergence	4240	3568	4240	3568	4585	3960	4585	4335	4585	3743	9.84
Anthesis	4585	3960	4953	4335	4953	4807	5377	6270	5529	4584	13.34
Hard dough	9140	9355	10019	9355	10223	9832	11595	11270	11183	10793	8.62

compared to that in case of GDD. The coefficient of variation was as high as 59.01% at CRI stage, which however, gradually reduced to 8.62% at hard dough stage.

Such high values of C.V. at CRI and tillering could be probably attributed to the prevalence of very low temperature and sunshine hours in the first four weeks of 1999-2000 crop season. Just like GDD, the HTU requirement was lower in the second season, which was due to less number of days taken to reach the phenophases (except at CRI and tillering stages where actually more number of days were taken for these events. In these two cases, relatively lower HTU values were recorded because of prevalence of low temperature and sunshine hours in these periods). On an average, the short and medium duration cultivars needed 4600 and 9654°day - hours for anthesis and hard dough stages, respectively. The corresponding values for long duration cultivars were 5440 and 11210 ^{0}day - hours.

Similar trends were observed in case of photo thermal unit requirement (Table 3). However, the C.V. values were relatively lower as compared to those in HTU because in the former case, maximum possible sunshine hour values are used, whereas in the later case, actual sunshine hours are used. This means that in real sense the HTU computation involves two meteorological variables viz., temperature and actual bright sunshine hours and hence such a high coefficient of variation is observed. The average PTU requirement for anthesis and hard dough in short and medium duration cultivars were 9703 and 16320 ^{0}day-hours, respectively whereas for long duration varieties, it was 10897 and 18597 ^{0}day-hours.

Heat use efficiency of the five cultivars in terms of biomass has been depicted in Fig. 1. The heat use efficiency, which gives us quantitative information regarding the efficiency in utilizing the heat energy of different varieties and within a variety, between different phenological stages. In all the cultivars it is seen that barring the initial 60-70 days of crop growth period, the HUE values were uniformly higher in the first season. In the second season, the HUE peaks were observed relatively earlier and were also

Table 3. Photothermal units taken to reach different phenological events (from sowing) in the five wheat varieties during 1998-99(I) and 1999-2000(II) crop seasons

Stages	HD2285		HD2329		PBW175		PBW343		C306		C.V.%
	I	II	I	II	I	II	I	II	I	II	-
Crown root initiation	2637	1879	2637	1997	2884	1997	2760	2077	2831	1997	17.31
Tillering	4906	3425	4971	3425	4971	3320	4971	3958	5098	3425	18.73
Bootleaf	7536	6688	7847	7033	8451	7846	8451	7846	8282	7488	7.51
Ear emergence	8904	7846	8904	7846	9774	8732	9774	9242	9774	8391	8.28
Anthesis	9774	8732	10225	9242	10225	10019	10829	12063	11048	9651	9.35
Hard dough	15586	16021	16702	16021	16993	16596	18982	18850	18385	18171	7.30

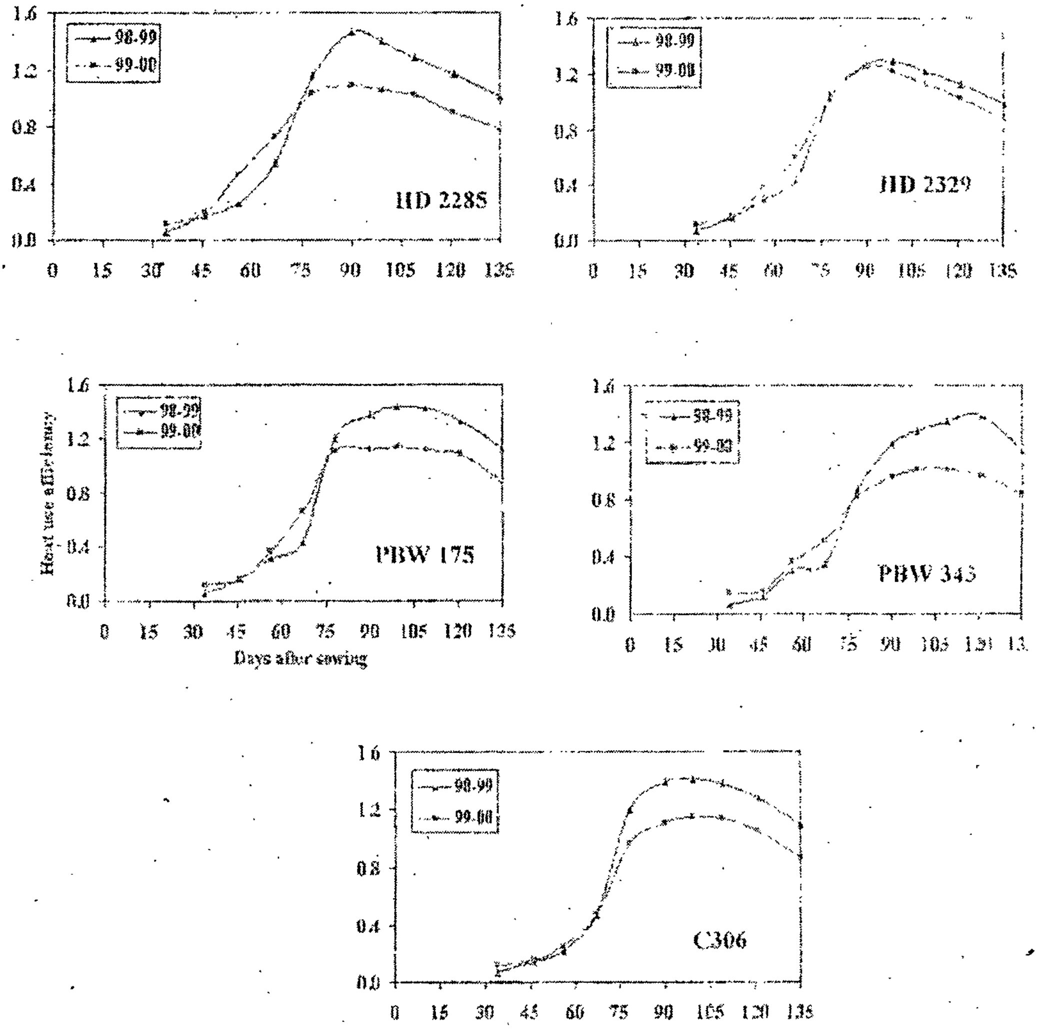

Fig. 1. Heat use efficiency (g/m²/° day) of five wheat cultivars in 1998-99 and 1999-2000 crop seasons

of lower magnitude. This shows that in this season the prevailing relatively higher ambient temperature conditions leading to a reduction in crop growth period resulted in lower heat use efficiency too. Such reduction in HUE due to delay in sowing were earlier reported by Agrawal *et al.* (1999) and Rao *et al.* (1999).

A look at the grain yields during these

Table 4a. Grain yield of the five varieties (t/ha) in 1998-99(I) and 1999-2000(II) crop seasons

Varieties	R_1	R_2	R_3	R_4	Mean
HD 2285					
I	4.25	4.85	3.60	5.23	4.48
II	4.78	4.48	4.55	4.61	4.61
HD 2329					
I	5.42	3.95	4.65	4.05	4.52
II	4.51	4.98	4.71	4.74	4.73
PBW 175					
I	3.80	3.40	4.90	5.57	4.42
II	4.52	4.13	4.01	4.30	4.24
PBW 343					
I	5.23	5.85	4.35	5.87	5.33
II	3.95	3.67	3.33	3.86	3.70
C 306					
I	3.65	3.30	3.00	2.65	3.15
II	3.31	2.75	2.82	3.10	3.00

C.D.(at 5%) : 1.179 for 1998-99 ; 0.290 for 1999-2000

two seasons (Table 4a) reveal that the differences in yields among the short and medium duration varieties viz., HD-2285, HD-2329 and PBW175 were minimumand negligible, of the order of 0.11 to 0.18 t/ha while the differences were appreciable in the two seasons in the long duration variety PB343. It is surprising to notice that the differences in the harvest index values among the five varieties and also between the two seasons are almost negligible (Table 4b), the values varying from 0.17 to 0.27 in the first season and from 0.18 to 0.31 in the second crop season.

This type of quantification of the thermal requirement for the crop growth and development in different varieties would be of immense use in the dynamic crop simulation studies.

Further, the thermal time units could be utilized for modeling studies in place of the number of actual days more effectively to quantify the yield and phenological development because of the low coefficient of variation values. Heat use efficiency is another index, which could be useful in the dynamic simulation models to evaluate different varieties in the different agro-ecological zones.

Table 4b. Harvest index of the five varieties in 1998-99(I) and 1999-2000(II) crop seasons

Varieties	I	II
HD2285	0.27	0.31
HD2329	0.27	0.29
PBW175	0.24	0.25
PBW343	0.28	0.24
C306	0.17	0.18

Thus, it can be inferred from these studies that though short duration varieties do not seem to have been much affected adversely due to the differences in the total accumulated heat from sowing to the different phenophases, some more detailed studies are required to establish such type of inferences as far as the long duration varieties are concerned.

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ECONOMICS OF PLANT GROWTH REGULATORS IN BRINJAL (*SOLANUM MELOGENA* L.) UNDER SEMI-ARID CONDITION OF RAJASTHAN

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ABSTRACT

The experiment was carried out at Horticulture Farm, SKN college of Agriculture. Jobner during the year 1997-98 to find out the economics of plant growth regulators in brinjal under semi-arid condition of Rajasthan. It was found that the yield of brinjal can be increased significantly by two successive spray of GA_3 and NAA at 35 and 45 days after transplanting. The maximum net profit of Rs. 107498.07/ha was obtained with the spray of 100 ppm GA_3 followed by 50 ppm (NAA (Rs. 102383.27/ha) as compared to control (Rs. 78493.07). The maximum cost: benefit ratio (1:5.60) was found with the spray of 50 ppm NAA. However, the higher concentration of GA_3 and NAA were found uneconomical.

Key words : Plant growth regulators, brinjal, semi-Arid.

Brijnal (Solaman melongena L.) is one of the popular vegetable grown extensively in all over the country. It is a heavy yielder and high remunerative crop but sometimes growers suffer with recurring economic loss due to poor plant vigour, low fruit setting and small fruit size. In general, under arid ecosystem the productivity of brinjal is very low due to prevailing edapho climatic constraints. Therefore, besides variety evolution standardization of location specific approach is very essential to improve the productivity of brinjal in semi-rid condition.

However, use of plant growth regulators have been found beneficial in improving plant growth, fruit set, fruit development, yield and quality of various solanaceous vegetables (Maurya & Lal. 1975; Sinha and Pal, 1983: Bose and Som, 1985) but efficacy varied with the different climatic conditions. Moreover, no information is available regarding economics of plant growth regulators in brinjal under semi-arid region, hence an investigation was undertaken to find out the effective and economical use of plant growth regulators in brinjal under semi-arid condition of Rajasthan.

MATERIALS AND METHODS

The experiment was carried out at Horticulture Farm, SKN College of

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Agriculture, Jobern during the year 1997-98. the climate of the locality is typically semi-arid, characterized by high atmospheric aridity and extremity of temperature both in summer and winter. The average annual rainfall and relative humidity was 500 mm and 57.6 to 80.8%, respectively. The experimental soil was sandy loam having 8.5 pH. During field preparation, a basal dose of FYM@20 t/ha was incorporated thoroughly before one month of transplanting. In addition to this, 100:50:50 kg/ha N:P:K was applied in two split doses i.e. first ½ N and full of P & K at the time of last ploughing of field but before transplanting and second dose of ½ N after 30 days of first application. The seed of brinjal cv. BR-112 was sown in well pulverized nursery beds during year 1997. Six week old seedling of brinjal cv. BR-112 were transplanted in the field at spacing of 60 × 60 cm during last week of July and light irrigation was applied just after transplanting.

The experiment was laid out in Randomized Block Design with 3 replication. The treatment comprised of GA$_3$, and NAA with 8 concentrations viz., GA$_3$, 50, 100, 150 and 200 ppm and NAA 25, 50, 75 and 100 ppm and control. The crop was sprayed these concentrations of plant growth regulators at 35 and 45 days after transplanting. The foliar spraying has been done with the help of compressed air hand sprayer by using teepol as a surfactant. The five plants were tagged randomly under each treatment. The observations regarding yield attributing traits and yield/ha were recorded and computed at final stage. Expenditure imposed on sprays, manuring, plant growth regulators in each treatment were worked out to obtain total cost. However, the net profit was obtained after deducting the cost of cultivation from gross return. In order to find out cost : benefit ratio the net return from individual treatment return. In order to find out cost : benefit ratio in net return from individual treatment was divided by their respective cost of cultivation which included cost of treatments also.

RESULTS AND DISCUSSION

The application of different plant growth regulators increased the yield and net return over the control. Cost of cultivation of brinjal crop was Rs. 17856.96 per ha which includes labour cost, tractor charges, irrigation, manuring and plant protection measures. Treatment wise additional cost is comprised different treatments of GA$_3$ and NAA (as in Table 1).

The yield (q/ha) of brinjal fruits under different treatments are given in table-1. the highest yield/ha was recorded under GA$_3$ 100 ppm (568.82 q/ha). The same finding was also reported by Patil *et al.* (1985). Ramanand *et al.* (1991) and Sharma et al. (1992). The gross return of brinjal was calculated at rate of Rs. 250/- per quintal. The net profit from cultivation under different treatments have been worked out after subtracting the cost of cultivation from gross return. Further, the maximum net profit of Rs. 107498.07 was obtained with the spray of GA$_3$ 100 ppm followed by 50 ppm NAA (Rs. 102383.27) as compared to control (Rs. 78493.07) but spray of 50 ppm NAA was found to be most economical which gave the maximum cost : benefit ratio

Table 1. Economics of various growth regulators in brinjal

Treatments	Quantity of growth regulators (g/ha)	Costa/ha (Rs.)	Cost of cultivation including cost of treatments (Rs.)	Yield(q/ha)	Gross return (Rs./ha) @Rs. 250/q	Net profit (Rs./ha)	C : B ratio
A. Concentration of GA_3							
GA_3 50 ppm	70.0	8400.00	26256.93	454.44	113735.00	87478.07	1:3.33
GA_3 100 ppm	140.0	16800.00	34656.93	568.82	142155.00	107498.07	1:3.10
GA_3 150 ppm	210.0	25200.00	43056.93	481.96	120490.00	77433.07	1:1.79
GA_3 200 ppm	280.0	33600.00	51456.93	473.00	118250.00	66793.07	1:1.29
B. Concentration of NAA							
NAA 25 ppm	35.0	208.00	18065.53	450.52	112630.00	94569.47	1:5.23
NAA 50 ppm	70.0	417.00	18274.13	482.63	120657.00	102383.27	1:5.60
NAA 75 ppm	105.0	625.00	18482.73	475.60	118900.00	100417.27	1:5.43
NAA 100 ppm	140.0	824.00	18691.33	463.50	115875.00	97183.67	1:5.19
C. Control	–	–	17856.93	385.40	96350.00	78493.07	1:4.39

Market price of brinjal Rs. 250/q Price of GA_3 and NAA = Rs. 120/g and Rs. 149/25g, respectively General cost of cultivation of brinjal crop per ha- Rs. 17856.93

(1:5.60) over the control (1:4.39). Where as higher concentrations of GA_3 and NAA decreased the yield and profit in brinjal considerably.

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QUALITY ASSESSMENT OF DIFFERENT ARID ZONE POMEGRANATE CULTIVARS

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ABSTRACT

An experiment was conducted to study the quality of different arid zone pomegranate cultivars. The fruit colour and shape varied among cultivars. Basin-seedless and (Ganesh × Khog) bright red coloured. Aril colour bright maroon red colour in Basin-seedless. (Khog × Ganesh and Khog × Jalore seedless) had low seed percentage with hard seeds. The arid percentage varied from 61% (Khog × Jalore seedless) to 68% (Muskut seedless × Ganesh and Basin seedless). Peel content also varied in different cultivars. The moisture, TSS, ascorbic acid, acidity, sugar content. Anthocyanin, sugar: acid ratio also varied in different cultivars.

Key words : Pomegranate, cultivars, arid zone.

Pomegranate is one of the important commercial arid zone fruit crop grown all over India for table and juice purposes owning to its hardy nature, versatile adaptability economical high yields, better keeping quality and export potential (Bankar and Prasad, 1992). It is indigenous to Iran but spread to India at early date. Although pomegranate of high quality is grown only there, where it is a cool winter and dry summer but it can still grow under wide range of climatic conditions. Farmers of dry region prefer to grow it due to its lesser water requirement and high recompanse. Though to assess any variety, yield is one of the important characteristics on the basis of which, farmers select cultivars yet quality of cultivars also carries because only good quality fruits fetch better market value. Keeping these detectives in consideration, quality of some cultivars of pomegranate was assessed under Jodhpur conditions.

MATERIALS AND METHODS

The present investigations were conducted to assess quality of arid-zone seven pomegranate cultivars and their crosses growing at the Horiculture farm of CAZRI, Jodhpur, which falls under semi-arid subtropical zone with annual rainfall varying from 150-300 mm. Three plants of each cultivar were selected for observations, five fruits from each plant, collected randomly were brought to laboratory in polythene bags at IARI, New Delhi and analysed for various characteristics such as fruit colour, shape, weight, grain colour, aril weight, specific gravity, seed percent and peel per cent.

The fruit colour and aril colour were noted with the help of the Horticultural colour chart. The fruit weight and seed weight were recorded with the help of laboratory balance. Specific gravity was measured as per method of Rangana (1986). A sample of seeds from each cv was taken and juice extracted by crushing and squeezing. Moisture, TSS, total sugars, reducing sugars, crude fibre, anthocyanins and ascorbic acid were determined as per method of Rangana (1986). The titratable acidity percentage was determined by titrating against N/10 NaOH using phenolpthalin as indicator.

RESULTS AND DISCUSSION

Physical characteristics

Colour and shape

It is very important character in pomegranate which determines consumer appeal, marketability and net return. The fruit colour of the different cultivars was either rose, pink or yellow with varying intensity. Shape of fruits varied from round to globose, however some of cultivars showed round to oblong shape. Cultivars (Ganesh × Khog and Basin seedless) were bright red coloured having desirable shape and were worth considering for further improvement programme (Table 1). Similar variation in colour and shape of fruits have also been reported by (Jagtap *et al.* 1992) and (Singh *et al.* 2001).

Table 1. Physical characteristics of different pomegranate cultivars

Cultivars	Fruit colour	Fruit shape	Grain colour	Seed hardiness
Eichakdana × Jalore seedless	Vermilion with yellowwish tinge	Round to globose	Yellowish pink	soft
Jalore seedless × Ganesh	Yellowish with scarlet tinge	Round to oblong	Bright pink	Soft
Khog × Jalore seedless	Prim-rose yellow	Oblong	French-Pink	Hard
Ganesh × Khog	Apple red	Oblong	White with slight pink tinge	Hard
Muskut seedless × Ganesh	Yellow with pinkish tinge	Round to oblong	Light pink red	Semi-soft
Basin-seedless	Apple red with yellowish tinge	Round	Bright mahroom red	Soft
Khog × Ganesh	Yellow with scarlet tinge	Globose	Whitish with pink tinge	Hard
C.D. at 5%		–	–	–

Aril colour

Red to deep red colour of aril is most attractive and desirable. In present study, bright maroon red colour was observed in Basin-seedless cultivar where as bright pink and french pink colour was noticed in cvs(Jalore seedless × Ganesh and Khog × Jalore seedless), respectively (Table 1). Therefore, it will be worth to use Basin seedless cultivar in further improvement as a source of red colour to improve aril colour of other cultivars. It has been reported that aril colour is inheritable in nature (Jagtap *et al.* 1992) and therefore there is ample scope to improve it.

Seed hardiness

The hardiness of seed stands as a foremost criterion for selecting a cv for improvement programme as also for commercial cultivation. In the present study, three cvs revealed hard seeds and three cvs soft seeds (Table 1). Almost all of these cultivars had higher seed percentage per fruit. (Khog×Ganesh and Khog × Jalore seedless) had low seed percueu tape per fruit but had very hard seeds. In this regard, Basin-seedless was the only best cv which had very soft seeds this cv has medium size fruits with good juice percentage and is worth for inclusion in breeding programme (Jagtap *et al.* 1992).

Fruit weight

Fruit weight attract the consumer at first sight. It increases the overall appeal and marketability of fruits. In present study, wide variation was observed in average fruit weight. It varied from 134.3 in (Khog × Ganesh) to 200.4 g in (Khog × Jalore seedless) (Table 2). Such variation in pomegranate fruit size was also reported by (Bankar and Prasad, 1992), (Al Khatni, 1992 and Singh *et al.* 2001). This variation in fruit size may be due to genetic factors and adaptability of cultivars in particular area.

Aril content and specific gravity

The aril percentage determines he edible portion/fruit and equally important for fruit size. In present study, it varied from 61% (Khog × Jalore seedless) to 68% (Muskut seedless × Ganesh and Basin-seedless (Table 2). Thus, these cultivars would be promising in hybridization programme for increasing the edible portion. Aril size is also another important character from quality point of view. Generally, medium to bold arils are preferred. Weight of 100 arils ranged from 21.73 g (Eichakdana × Jalore seedless) to 29.41 (Khog × Ganesh). All the other cultivars showed intermediate results. Specific gravity ranged from 0.92 in cvs (Ganesh × Khog and Khog × Jalore seedless) to 0.98 in cv (Jalore seedless × Ganesh) indicating the intervarietal differences as significant. These results are in accordance with the findings of Patil and Sanghavi, 1980; Jagtap *et al.* 1992 who obtained similar results while working on above parameters in pomegrats.

Peel content and Rind thickness

Peel content in different cultivars ranged from 32% (Muskut seedless × Ganesh and Basin seedless) to 38% (Khog × Ganesh) (Table 2). Lesser the peel percentage more is the edible portion. Hence,

Table 2. Physical characteristics of different pomegranate cultivars

Cultivars	Fruit weight (g)	Specific gravity	Rind thickness (cm)	Peel (%)	Grain (%)	100 arils weight (g)	Grain Peel ratio	Juice (%)
Eichakdana × Jalore seedless	164.9	0.97	0.36	36	64	21.73	1.77	63
Jalore seedless × Ganesh	186.9	0.98	0.37	36	65	22.37	1.81	64
Khog × Jalore seedless	200.4	0.92	0.39	39	61	23.80	1.56	48
Ganesh × Khog	168.2	0.92	0.33	37	63	21.83	1.70	47
Muskut seedless × Ganesh	163.0	0.97	0.34	32	68	22.72	2.12	52
Basin-seedless	165.0	0.96	0.34	32	68	26.31	2.12	65
Khog × Ganesh	134.3	0.95	0.36	38	62	29.40	1.63	49
C.D. at 5%	8.0	0.03	–	–	–	0.90	0.68	–

the genotypes having lesser peel content can be incorporated in further breeding programmes to increase the edible portion of fruits. Rind thickness is one of the most important quality parameter, which gives criterion of market value for fruits. Maximum rind thickness 0.39cm was observed in cv (Khog × Jalore seedless) whereas minimum rind thickness 0.33 cm was recorded in cv (Ganesh × Khog). Similar variation for rind thickness in different cultivars has also been reported by Misra *et al.* 1983 and Malhotra *et al.* 1983.

Chemical characteristics

Juice content

The real nutritionally important edible matter of pomegranate fruit is revealed by the juice content of the fruit. In present study, this character showed very wide variation which ranged form 47% in (Ganesh × Khog) to 65% in (Basin seedless) (Table 3). The sweet acidic juice of pomegranate has exquisite quality being an attribute of economic significance according to Patil and Karale, 1985, processed products such as bottled juice, juice concentrate, syrup and jelly are highly appreciated.

Moisture and TSS

The moisture content of different cultivars ranged from 79.6 per cent in cv (Khog × Jalore seedless) to 82.2 per cent in cv (Basin seedless) and the intervarietal differences were recorded to be significant. The T.S.S. ranged from a minimum of 14.89 in cv (Khog × Ganesh) to a maximum of 18.00 in cv (Eichakaana × Jalore seedless) and cv

Table 3. Chemical characteristics of different pomegranate cultivars

Cultivars	Moisture (%)	TSS (°Brix)	Acidity (%)	Vitamin C (mg/100g)	Sugar (%) Reducing	Sugar (%) Total	Anthocyanin (mg/100g)	Crude fibre(%)	Sugar : Acid ratio
Eichakdana × Jalore seedless	80.0	18.0	1.15	21.73	14.86	15.46	17.92	5.20	15.63
Jalore seedless × Ganesh	81.6	16.0	1.66	22.37	13.15	13.42	39.72	5.40	10.22
Khog × Jalore seedless	79.6	17.0	0.98	23.80	12.91	13.21	22.05	6.10	16.39
Ganesh × Khog	79.9	16.0	1.43	21.83	13.19	14.07	10.38	7.20	11.87
Muskut seedless × Ganesh	81.5	18.0	1.27	22.72	13.16	13.72	19.72	4.40	7.35
Basin-seedless	82.2	17.0	2.91	26.31	14.26	15.02	77.85	4.50	5.69
Khog × Ganesh	79.8	14.9	1.45	29.41	14.82	15.27	12.88	3.80	11.71
C.D. at 5%	2.5	1.3	0.10	0.80	0.80	0.97	2.86	0.37	0.48

(Muskut seedless × Ganesh) (Table 3). Similar results has also been reported by Al-khatni, 1992 and Singh *et al.* 2001 which working with different cultivars of pomegranate.

Acidity

Citric and malic acids have been identified as the major acids in pomegranate juice (Ulrich, 1970). In the germplasm evaluated, highest value for acidity 2.91% was recorded in cv Basin-seedless whereas lowest value 0.8% in Khog × Jalore seedless. Intervarietal differences were significant (Table 3). The prevalence of wide variation in acid content for different cultivars is the probable reason to use this character as a basis of classification of pomegranate cultivars as sweet, sour or bitter sweet (Saxena *et al.* 1984, Bankar and Prasad, 1992 and Singh *et al.* 2001.

Ascorbic acid

Ascorbic acid determines the nutritional value of fruit by acting as an antioxidant and aiding the body defence mechanism. The ascorbic acid content ranged from 21.73 in cv (Eichakdana × Jalore seedless) to 29.41 cv. (Khog × Ganesh) (Table 3). In General, the values for ascorbic acid reported by Malhotra and Jawanda, 1983 but were within the range reported by Saxena *et al.* 1984. The genotypes having higher ascorbic acid content hence can be used to in future programmes for breeding to increase the nutritive and medicinal value of fruits.

Anthocyanin content

Anthocyanins provide bright red to

purple colour of fruits. These are the pigments responsible for bright red and shiny look of pomegranate arils. As high as 77.85 mg/100g anthocyanin was recorded in cv (Basin Seedless) followed by 39.72 mg/100 g in cv (Jalore seedless × Ganesh) with lowest 10.38 mg/100g in cv (Ganesh × Khog) (Table 3). Hence, Basin seedless cv has maximum probability of using as a parent to raise progeny having bright red aril colour.

Sugar content

Sugars provide the real taste and flavour to fruits. In pomegranate glucose and fructose are major sugars. cultivar Eichakdana × Jalore seedless recorded maximum total sugars 16.39% as compared to all other cultivars under investigation. Hence, this cv was found suitable for table purpose as well as for processing into juice, R.T.S., Nector and Anar-rub. The intervariatel differences for total as well as for reducing sugars were found to be significant. In reducing sugar, all the cvs were quiet rich. The accumulation of sugars, particularly a high fraction of reducing sugars may be attributed to the genetic characteristics of this fruit. Malhotra and Jawanda, 1983; Saxena *et al.* 1984 reported as high as 90% of total sugars as reducing sugars in pomegranate.

Crude fibre

Crude fibre act as laxative and aid in digestion. They prevent constipation and lowers the blood cholesterol level. The values for crude fibre ranged from 7.20 to minimum of 3.80 (Table 3). These factors are also important in deciding seed softness character of pomegranate fruits (Al-Khatni, 1992).

Sugar : acid ratio

The maximum value of sugar : acid ratio 16.39 was obtained in cv (Khog × Jalore seedless) indicating it to be sweet cultivar fit for table and juice purpose whereas minimum value 5.69 was observed in cv (Basin-seedless) (Table 3). Indicating it to be a sour cultivar fit for Anardana, Anar chutney or formulations where acidic taste is required reported by Singh *et al.* 2001.

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CHARACTERIZATION OF LOW TEMPERATURE PROTECTION PRACTICES FOR TOMATO

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ABSTRACT

A field experiment was conducted on loamy sand soil during *rabi* 1998-99 at Ludhiana, Punjab, to evaluate the effect of five protective treatments against low temperature effects in tomato. The treatments of light irrigation when frost was expected; rice straw mulch; overhead plastic cover and control. Overhead plastic cover resulted in maximum increase of air temperature at 10 cm height above the ground by 1.8°C during morning and 2.9°C in afternoon compared to control and also increased the average soil temperature at 5 cm depth both during morning and afternoon by 1.6°C and 2.2°C, respectively, over control. Polythene mulch resulted in maximum increase of average soil temperature, which was higher than control by 2°C during morning and 2.7°C during afternoon. Straw mulch showed 1.1 °C higher average soil temperature over control in morning but lowered the afternoon temperature by 2.7°C. Overhead plastic cover, polythene mulch and straw much provided 22.4, 19.2 and 16.5 percent higher tomato yields, respectively, over control. Extra light irrigation did not show any increase in yield over control.

Key words : Tomato, frost, minimum temperature, polythene cover, mulch.

The North Western plains of India experience sub tropical climate and the temperature goes to such low levels in winter, which affects sensitive crops. During December to February, these areas may experience moderate to severe cold spells with even occasional frost. Among vegetable crops, tomato is very sensitive to low temperature and frost, as it cannot withstand even mild frost. Nandpuri *et al.* (1995) reported that frost injury occurred in some varieties of tomato grown at Ludhiana, Punjab. Tanaka and Yashi (1986) reported that minimum night temperature around 2.5°C in the early stages of plant growth greatly retarded stem and leaf development and delayed flower opening. Use of mulch materials was reported to be favourable for tomato crop against low temperatures (Liakatas *et al.* 1986; El-hassan 1986; Kim *et al.* 1988; and Chamabasa-vanna and Setty, 1991).

MATERIALS AND METHODS

Field study was conducted with tomato crop (var S-22) planted on 13th November 1998 at Ludhiana (30°56' N latitude and 75°52' E Longitude and 247 m above mean sea level) on a loamy sand soil. Five treatments namely : light irrigation when frost was expected (protective irrigation), rice straw mulch, polythene mulch, overhead plastic cover and control were compared. Overhead plastic cover, polythene mulch and straw mulch were initiated on 11th December, 1998 and were terminated on 11th March, 1999. Protective irrigation were given on 13th January and 4th February. The crops were planted on ridges spaced 75 cm row to row and 30 cm plant to plant. Fertilizers @ 50 kg N, 62.5 kg P_2O_5 and 62.5 kg K_2O per hectare were drilled and additional 87.5 kg N/ha was side dressed at 90 days after planting.

Soil temperature at 5 cm depth were recorded with soil thermometers embedded in the centre of the plots daily at 0730 and 1430 hours IST from 19-12-1998 to 26-2-1999. Similarly, air temperature were also recorded at 10 cm above the ground. Periodic measurements of canopy temperature and canopy-air temperature difference were made at 1430 hours on selected clear days with the help of a hand held portable infrared thermometer. Soil moisture was measured thermo gravimetrically from soil depth of 0-15, 15-30, 30-60, 60-90 cm on selected days and the depths of water (cm) retained in the 0-90 cm root zone were obtained. Leaf water potential measurements were made at 1430 hours with the help of a pressure chamber apparatus on the selected days when soil moisture observations were also taken. Two plants were sampled at random from each plot for dry matter accumulation. The samples were oven dried at 60°C before recording dry weight. The yield was recorded from each net plot at each harvest and yield expressed on per hectare basis.

RESULTS AND DISCUSSION

Soil temperature

Polythene mulch treatment recorded highest soil temperature and showed an average overall increase of 2.2°C over control in the morning and 2.7°C in the afternoon. Polythene mulch was followed by overhead plastic cover which also showed an average increase of 1.8°C over the control in the morning and 2.9° C in the afternoon. Straw mulch also increased the average soil temperature above control by 1.1°C in the morning but it lowered the afternoon soil temperature below control by 2.7°C.

Air temperature

Overhead plastic cover treatments recorded the highest air temperature both during morning and afternoon. The increase was 1.8°C above control in morning and 2.9° C in the afternoon. The air temperature recorded for polythene mulch was also higher both in morning and afternoon over the control but the magnitude of the increase was less than that for the overhead plastic cover treatment.

Canopy temperature and Canopy-air temperature difference

Mulches (either straw or polythene) treatments resulted in lower canopy temperature and also more negative canopy-air temperature differences. These canopy temperature and canopy-air temperature differences trends correspond with those reported for soil water status under different treatments.

Soil moisture

General trend revealed maximum soil water storage under straw mulch followed by polythene mulch and overhead plastic cover treatments compared to control or protective irrigation treatments. The straw mulch conserved the highest soil moisture because organic mulches reduced

Table 1. Average soil temperature, air temperature, canopy temperature and canopy-air temperature differences under different treatments

Treatment	Temperature (°C)					
	Soil temperature at 5 cm depth		Air temperature at 10 cm above the ground		Canopy temperature	Canopy-air temperature
	0730 hr.	1420 hr.	0730 hr.	1430 hr.	1430 hr.	1430 hr.
Control	9.7	19.4	7.3	19.1	19.1	-2.9
Protective irrigation	9.7 (0.0)	19.3(-0.1)	7.5(0.0)	18.9(-0.2)	18.6	-3.2
Straw mulch	10.8(+1.1)	16.7 (-2.7)	7.9(+0.4)	19.1(0.0)	18.0	-3.5
Polythene mulch	11.7(+2.0)	22.1(+2.7)	8.0(+0.5)	19.5(+0.4)	18.3	-3.3
Over head plastic cover	11.3(+1.6)	21.6(+2.2)	9.3(+1.8)	22.0(+2.9)	18.5	-3.1

Table 2. Soil water status in root zone and xylem water potential under different treatment

Treatment	Soil water retention (cm of water/ 90 cm root zone)				Xylem water potential (bars)			
	DAS			Mean	DAS			Mean
	36	51	90		36	51	90	
Control	14.2	14.1	13.6	13.9	-16.6	-17.5	-17.7	-17.3
Protective irrigation	174.1	14.2	14.8	14.4	-16.5	-17.6	-17.3	-17.1
Straw mulch	16.8	16.3	15.5	16.2	-15.7	-16.1	-16.2	-16.0
Polythene mulch	16.5	16.2	15.2	16.0	-15.9	-16.3	-16.5	-16.3
Over head plastic cover	16.3	16.0	14.3	15.5	-16.1	-16.7	-16.8	-16.5

evaporation of water. Straw mulch also reduces evaporation by intercepting the solar energy that may reach the soil surface (Hillet *et al.*1995). Improvement in the water use efficiency of crops through evaporation reduction by residues has been reported by Unger (1986), Sharma and Gupta (1987). Increase in soil moisture content with application of polythene mulch was reported by Kim *et al.* (1988), Bogle *et al.* (1989) and Decoteau et al., (1985).

Xylem water potential (XWP)

The mulches (either straw or polythene) treatment resulted in less negative water potential on all days. This xylem water potential trend corresponds with those reported for soil water potential on all days. This trend in XWP also agree with that of canopy temperatures. Pandey *et al.* (1985) also observed a close correlation between XWP and canopy temperature of beans. Similar observations were reported for winter maize by Sumayao *et al.* (1980).

Dry matter accumulation of tomato under different treatments

The periodic dry matter production in tomato (Table 3) showed difference under different treatments. The total dry matter accumulation was maximum under overhead plastic cover at all stages of crop growth, which was followed by plastic mulch and straw mulch treatments. The dry matter production under protective irrigation was at par with the control treatments.

Yield

Tomato fruit yield under various treatments are shown in Table 4. Overhead plastic, straw mulch and polythene mulch treatments gave significantly greater yield over protective irrigation and control treatments. Maximum yield was observed under plastic cover, which was significantly higher than all other treatments except polythene mulch. The yield observed under

Table 3. Dry matter accumulation (g/m^2) of tomato under different treatments

Treatment	Days after planting								
	45	60	75	90	105	120	135	150	165
Control	40.9	87.2	19.14	203.9	301.6	313.2	325.9	323.1	318.6
Protective irrigation	43.2	87.7	192.9	208.7	307.7	317.0	330.2	327.2	321.1
Straw mulch	41.4	94.7	205.7	250.3	353.4	372.1	381.7	370.2	345.5
Polythene mulch	42.1	95.1	210.3	254.2	354.1	375.3	386.3	376.8	353.1
Over head plastic cover	43.0	97.5	212.3	257.0	356.4	379.5	389.8	379.4	365.6
C.D. (P=0.05)							14.1	11.2	6.4

Table 4. Effect of different treatments on yield of tomato

Treatment	Yield of tomato (kg/ha)
Control	47518
Protective irrigation	47445
Straw mulch	55375
Polythene mulch	56656
Over head plastic cover	58171
C.D. (P=0.05)	1188

polythene mulch was statistically at par with that under plastic cover. Similarly, yields under straw mulch were also statistically at par with polythene mulch. These results showed similarity with some studies reported else where. Firake *et al.* (1994) obtained higher yield in transparent plastic tunnel, sugar cane trash mulch, black polythene mulch and transparent polythene mulch. Similarly Bogle *et al.* (1989), Decoteau *et al.* (1985) and Gunadi and Suwanti (1988) also observed higher tomato yields with application of different types of mulches .

Higher yield with overhead plastic cover or mulches was the result of better micrometeorological condition in terms of air temperature, soil temperature and soil moisture status, the results of this study reveals than tomato crop can be protected from adverse effects of low temperature with the use of overhead plastic cover or polythene mulch or straw mulch during winter months.

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PHYSIOLOGICAL STUDIES ON POD AND SEED CHARACTERS IN RELATION TO PRODUCTIVITY IN GARDEN PEA

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ABSTRACT

An experiment was carried out to understand the pattern of various growth events occurring during fruit development in garden pea. The pod rapidly increased in length till 35 days after flowering (DAF) and in width till 30 DAF in both the genotype, Arkel and GP-4. There was differential response reserved in fresh weight, GP-4 has shown significantly high fresh weight of pod as well as of seeds. The dry weight of pod and seeds increased in a sigmoidal pattern for both the genotypes.

Key words : Dry weight, fresh weight, garden pea, pod length, pod width.

Garden pea (*Pisum sativum* L. sub sp. *hortense* Asch. and Graebn.) is an important legume crop mostly consumed for its edible green seeds. This crop is important from nutritional point of view, as it is a rich and cheap source of protein. Understanding the growth and development of reproductive organs is an important basis for investigating causes of yield variation. The final seed yield is the result of the rate and duration of effective grain filling in blackgram (Babu *et al.* 1985) and in greengram (Srinivasan *et al.* 1985). Information regarding pod and seed development is lacking in garden pea and there is a dire need for studying the complexity of pod and seed growth patterns. Hence the present study was conducted to understand the growth pattern of pod and seed development and to find out the effective grain filling period in garden pea.

MATERIALS AND METHODS

The investigation was carried out at the Research Farm of Indian Agricultural Research Institute, New Delhi during the *rabi* season of the year 1999-2000, to study the pod and seed development patterns in two genotypes of pea, namely Arkel and GP-4. The experiment was laid out in completely randomized design with three replications. Five hundred just opened flowers were tagged at fifty per cent flowering between 10 A.M. to 12 P.M. in each replication. Age of the seeds of just opened flowers was taken as zero. Ten pea pods were harvested randomly from tagged flowers for periodical observation at fixed intervals starting from few days after anthesis up to maturity of pods i.e., when the pods/seeds were 5, 10, 15, 20, 30, 35, 40 and 45 days old. Observations were recorded for the length and width, fresh and dry weight of the developing pods and seeds. The mean values of ten pods were considered in assessing the growth pattern of the characters.

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RESULTS AND DISCUSSION

Growth of pod, from fertilization to maturity is a complex process. The initial growth-of pod just after fertilization is very slow. The slow rate of growth at beginning stages of pod development appears to be a common phenomenon in legumes (Shibles *et al.* 1975 and Babu *et al.* 1985)

Length of the developing pod

Woodroof and William (1955) stated the length of the fruits is one of the factors involved in fruit maturation. The length of the pod increased significantly till 25 DAF in both Arkel and GP-4 and remained almost unchanged till 35 DAF after which there was a slight decrease in length. However, the pod length was found significantly high in GP-4 since ten DAF and maintained its superiority till 45 DAF (Table 1). Manohar and Sachan (1975) reported that the mean pod length in pea increased rapidly till 14 DAF and remained almost unchanged till 38 DAF and then recorded slight decrease due to dehydration and shrinkage of maturing pods. Similar trend of observations were reported in small edible podded pea (Ketsa and Pooputtarang, 1991) and in pigeon-pea (Pradhan and Bera, 1995).

Width of the developing pod

The pod width rapidly increased up to 20 DAF and then there was not much change recorded till 45 DAF in both the genotypes. In this trait also significantly

Table 1. Length and width of the pod (cm) at different days after flowering in two genotypes of pea

Days after flowering	Length Genotypes Arkel	GP-4	Mean	Width Genotypes Arkel	GP-4	Mean
5	2.34	2.30	2.32	0.50	0.63	0.57
10	4.70	4.88	4.79	1.19	1.26	1.23
15	7.07	7.19	7.13	1.31	1.56	1.44
20	7.73	8.04	7.89	1.34	1.63	1.49
25	8.07	8.39	8.23	1.35	1.65	1.50
30	8.16	8.56	8.36	1.36	1.66	1.51
35	8.20	8.61	8.41	1.36	1.66	1.51
40	8.19	8.60	8.40	1.34	1.65	1.50
45	8.17	8.56	8.37	1.31	1.63	1.47
Mean	6.96	7.24		1.23	1.48	
	Genotypes (G)	Days (D)	G×D	G	D	G×D
SEm±	0.047	0.100	0.142	0.011	0.022	0.032
C.D. 5%	0.135	0.286	0.40	0.03	0.06	0.091

higher values were obtained in GP-4 as compared to Arkel (Table 1). Similar trend of results were reported in black gram (Babu *et al.* 1985) and in mungbean (Dharmalingam and Basu, 1990).

Fresh weight of the developing pod and seeds

The fresh weight of pod increased significantly till 30 DAF in Arkel and 40 DAF in GP-4(Table 2). The increase in fresh weight of seeds per pod in both the genotypes was significant till 40 DAF. Thereafter, they showed significant decrease at 45 DAF due to dehydration and shrinkage in both the genotypes (Table 2). Manohar and Sachan (1975) reported that the pea pods showed continuous increase in mean fresh weight till 33 DAF and thereafter recorded continuous decrease. Bell shaped trend were also reported in terms of fresh weight for growth of pod as well as seeds in blackgram (Babu *et al.* 1985; Das and Sen, 1989) and in pigeon-pea(Pradhan and Bera, 1995).

Dry weight of the developing pod and seeds

The increase in dry weight of pod for both Arkel and GP-4 was significant till 40 DAF after which the increase was nonsignificant (Table 3). The dry weight of seeds per pod increased significantly till 45 DAF in both the genotypes. Based on dry matter growth, the seed development in garden pea can be divided into three distinct phases. First phase beginning from anthesis up to tenth day was marked by a slow increase in weight. From tenth to fortieth day was the second phase during which period there was a rapid accumulation of dry weight and this period can be said as the effective period of grain filling garden

Table 2. Fresh weight of the developing pod(g) and seeds per pod at different days after flowering in two genotypes of pea

Days after flowering	Fresh weight of pod Genotypes Arkel	 GP-4	Mean	Fresh weight of seeds per pod Genotypes Arkel	 GP-4	Mean
5	0.24	0.37	0.31			
10	1.60	1.46	1.53	0.04	0.02	0.03
15	2.34	2.60	2.47	0.10	0.08	0.09
20	3.29	3.45	3.37	0.37	0.41	0.39
25	3.52	4.00	3.76	0.66	0.83	0.75
30	3.71	4.54	4.13	1.23	1.47	1.35
35	3.86	5.16	4.51	1.73	2.24	1.99
40	3.97	5.37	4.67	2.11	2.62	2.37
45	3.05	4.32	3.69	1.83	2.42	2.13
Mean	2.84	3.47		1.009	1.26	
	Genotypes (G)	Days (D)	G×D	G	D	G×D
SEm±	0.03	0.06	0.09	0.013	0.026	0.037
C.D. 5%	0.086	0.183	0.25	0.037	0.074	0.105

Table 3. Dry weight of the developing pod (g) and seeds (g) per pod at different days after flowering in two genotypes of pea

Days after flowering	Dry weight of pod: Genotypes Arkel	Dry weight of pod: Genotypes GP-4	Mean	Dry weight of seeds per pod: Genotypes Arkel	Dry weight of seeds per pod: Genotypes GP-4	Mean
5	0.03	0.05	0.04			
10	0.12	0.17	0.15	0.004	0.002	0.003
15	0.25	0.30	0.27	0.018	0.014	0.016
20	0.42	0.48	0.45	0.042	0.060	0.051
25	0.54	0.64	0.59	0.108	0.131	0.120
30	0.65	0.79	0.72	0.236	0.280	0.258
35	0.74	0.89	0.81	0.401	0.459	0.430
40	0.80	0.97	0.89	0.513	0.577	0.545
45	0.81	0.98	0.90	0.605	0.651	0.628
Mean	0.48	0.58		0.241	0.272	
	Genotypes (G)	Days (D)	G×D	G	D	G×D
SEm±	0.004	0.082	0.012	0.003	0.006	0.008
C.D. 5%	0.011	0.023	0.033	0.008	0.016	0.023

pea. From 40th day to 45th day was again another phase of growth with slow rate of dry weight increase. Garden pea therefore takes 45 days from anthesis to maturity. Similar sigmoidal trend in pod and seed growth with respect to dry weight was reported in greengram (Srinivasan *et al.* 1985), pigeon-pea (Pradhan and Bera, 1995) and in french bean (Bingliang et al., 1997).

The present study shows that the pods develop most rapidly till 35 DAF with respect to length, 20 DAF regarding width and 40 DAF regarding fresh weight and differential response was observed in both the genotypes under study. It is concluded that superiority of all the pod and seed characters of GP-4 may be used as desirable traits in breeding programme to obtain higher productivity levels. The highest yield of green, marketable pod can be obtained when harvested between 30-35 days after flowering. This will also enable to fetch higher economic returns to the growers.

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STUDIES ON THE MINIMUM ISOLATION REQUIREMENTS FOR HYBRID SEED PRODUCTION IN CHILLI (*CAPSICUM ANNUUM* L.)

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ABSTRACT

An experiment was conducted to study the minimum isolation distance requirements for hybrid seed production of chilli. The male sterile plants of MS-12 were taken as seed parent and male fertile as pollen parent while LIS served as contaminator. The study revealed a distance pattern in percentage out crossing in different mini hybrid seed production plots. As the distance of mini hybrid seed production plot was increased from contaminator plot, a significant reduction was recorded in the percentage out crossing. The highest average out crossing of 11.66% was recorded in the mini hybrid seed production plot which was spaced at 25 m distance from contaminator plot. followed by 9.64%, 9.07%, 7.10%, 6.10%, 3.47%, 2.02%, 0.94%, 0.00, 0.00 at 50 m. 75m, 100m, 125m, 175m, 150m, 175m, 200m, 225m, 250m, respectively. Hence, it may be concluded that a minimum isolation distance of 225 m from contaminator was safe to produce the 100% pure hybrid seed in chilli.

Key words : Chilli, hybrid seed, isolation distance.

Genetic purity is the primary attribute of a quality seed to realize maximum dividends. Besides mechanical admixtures natural out crossing vitiates the genetic purity of a crop variety. Chances of genetic contamination by mechanical admixtures can be minimized by complete sanitation of the cultivar from foreign material during the crop production period and outcrossing can be reduced by keeping a proper isolation distance from contaminants. The extent of genetic contamination through natural out crossing depends mainly on the system of reproduction, isolation distance from the contaminants, pollinator activities, speed and direction of wind. In chilli the out crossing has been reported to range from 7-92%. Extent of out crossing and pollen dispersal behavior under given agro-climatic conditions determines the minimum isolation requirements for seed production of a particular variety and no systematic information is available regarding this in chilli. Therefore, present investigation was undertaken to standardize the minimum isolation distance required for quality hybrid seed in chilli.

MATERIALS AND METHODS

Planting materials

The experiment was conducted the

Experimental Area, Seed Technology Centre, Punjab Agricultural University, Ludhiana, (33^0 55' N latitude; 75^0 54' E longitude; 247 m above mean sea level), India during 1999-2001. The experimental material for the present investigation included the parental lines of Chilli Hybrid -1 (CH-1) viz. male sterile line, (MS-12; erect fruiting habit; recessive) and Ludhiana Local Selection, (LLS; dropping fruiting habit; dominant). The male sterile plants of MS-12 were taken as seed parent and male fertile as pollen parent while LLS served as contaminator. A rectangular plot (5.4 × 4.5m^2) of LLS with plant spacing of 60×45 cm was planted towards the southeastern side of the experimental plot. Ten mini hybrid seed production plots (MHSPP) of 4.8 × 3.6m^2, with plant spacing of 60×22.5 cm were planted in northwestern side of the experimental plot by keeping 25 m distance between two plots up to 250 m. The land between these plots was kept fallow so that no hindrance could be there for wind velocity and pollinator activities. The experiment was replicated thrice. A screening process was carried out as flowering stage by examining the characters of flowers, during which fertile plants (Swollen anthers and pollen) were rouged out from seed parent rows and sterile from pollen parent rows, thus, maintaining a row ratio of seed and pollen parent as 3:1.

Wind direction and speed

During flowering period (May 2000-October 2000) the daily meteorological data regarding wind direction and wind velocity was obtained from the meteorological observatory of Punjab agricultural University, Ludhiana, India.

Insects visiting the crop

Insects visiting the crop during blooming period were noted in general and collected with hand new and sorted out in to various species.

Natural crossing :

Five plants of seed parent were randomly selected and tagged in each MHSPP. The observations were recorded for number of fruits per plant and number of seeds per fruit.

Progeny test

Ripe fruits were harvested from tagged seed parents of each MHSPP separately. Seed samples were used to screen the progeny for frequency of plants with pendulous fruits and estimating the extent of out crossing in different MHSPP. The percent outcrossing was calculated as follows :

Out Crossing percentage : Number of plants with pendulous fruiting/Total number of plants (pendulous and erect) × 100

Statistical Analyses : Statistical analyses of this data was done as per ANOVA in split plot design as suggested by Cochran and Cox (1967).

RESULTS AND DISCUSSION

Insects visiting the crop

Insects observed during flowering period were *Apis mellifera, Dorylus labiatus* Shunk, *Epilachna viginlioctopuntata, Rhapdopalpa foveicollis* Lucas, Polisteshibraeus Fabricius, *Musca domestic and Dipterous flies.*

Fruit number per plant

The biometrical observations were recorded to be significant (P>0.05) for fruit number per plant under different harvesting and nonsignificant in different MHSPPs along with their interaction. The number of fruits per plant ranged from 80.75 to 85.80 in different MHSPPs and 64.19 to 101.87 under different harvesting. The fruit number was significantly higher in second harvesting (101.87) followed by third (86.6), first (74.65) and fourth harvesting (64.19), as shown in Table 2.

Seed number per fruit

The biometrical observation were nonsignificant for seed number per fruit interchange under different harvesting as well as in different MHSPP. The seed number per fruit ranged from 15.11 to 17.52 in different MHSPPs and 16.38 to 17.75 under different harvesting, (Table 3).

Percentage out crossing

The percent out crossing was significant (P<0.05) in different MHSPPs as well as under different harvesting along with their interaction. The maximum out crossing of 11.66 was recorded as 25m distance from contaminator. This was followed by 964, 9.07%, 7.10%, 6.10%, 3.47%, 2.02%, 0.94%, 0.00, 0.00 percent outcrossing at 50 m, 75m, 100m, 125m, 150m, 175m, 200m, 225 m, isolation distances respectively. No out crossing was recorded at an isolation distance of 225m and beyond it. Different harvesting also revealed significant variation in out crossing. The maximum average out crossing was recorded in second harvesting 6.36%

Table 1. Number of fruits per plant in different mini hybrid seed production plots planted at different isolaiton distances from Ludhiana Local Selection (L.L.S.)

	Distance (m)										
Harvesting Dates	25	50	75	100	125	150	175	200	225	250	Mean
H1	76.90	79.70	73.40	79.20	78.50	73.70	69.20	70.30	72.10	73.5	74.65
H2	97.36	102.70	108.00	99.00	105.00	101.00	108.60	102.80	97.80	96.10	101.87
H3	80.30	79.50	88.70	90.80	90.80	88.70	87.90	82.00	85.00	92.70	86.61
H4	68.10	61.40	63.40	68.90	68.90	59.00	64.70	70.00	58.00	63.4	64.19
Mean	80.75	80.82	83.37	84.47	85.8	80.60	82.6	81.27	78.22	81.42	
C.D. (P=0.05)	Harvesting			5.6							
	Distance			NS							
	Harvesting × Distance			NS							

Table 2. Number of seeds per fruit in different mini hybrid seed production plots planted at different isolation distance in Chilli

	Isolation Distance (m)										
Harvesting Dates	25	50	75	100	125	150	175	200	225	250	Mean
H1	16.09	17.22	16.48	14.02	17.14	15.42	16.20	16.80	17.57	16.90	16.38
H2	18.30	1.12	15.36	16.68	17.90	18.90	19.20	17.40	16.70	18.96	17.75
H3	18.20	17.12	15.90	15.20	17.70	18.20	17.80	18.50	16.20	16.12	17.09
H4	17.48	14.65	16.20	14.56	17.20	16.58	16.30	15.20	16.32	16.22	16.06
Mean	17.52	16.78	15.98	15.11	17.48	17.27	17.37	16.47	16.69	16.02	

C.D. (P=0.05)	Distance	NS
	Harvesting	NS

Table 3. Effect of different isolation distances on the per cent outcrossing in Chilli

	Isolation Distance (m)										
Harvesting	25	50	75	100	125	150	175	200	225	250	Mean
H1	12.90	9.20	8.60	7.20	7.00	5.80	4.90	1.90	0	0	5.75
H2	14.76	11.46	11.30	10.90	8.70	4.70	.70	1.08	0	0	6.36
H3	9.70	9.00	8.30	4.60	4.90	1.30	1.20	0.78	0	0	3.98
H4	9.30	8.90	8.10	5.70	3.80	2.10	1.30	0	0	0	3.92
Mean	11.66	9.64	9.07	7.10	6.10	3.47	2.02	0.94	0	0	

C.D. (P=0.05)	Isolation distance	0.75
	Harvesting	0.59
	Harvesting ^ Isolation Distance	1.87

followed by first (5.75%), third (3.98%) and fourth (3.92%).

There seems to be no earlier report in literature, which can give any information regarding isolation requirements for hybrid seed production of chilli and the factors affecting it. The contaminator plot was apparently planted towards the southeastern side of the experimental plot on the basis of relevant literature and data taken from the Metrological Department, Punjab Agriculture University, Ludhiana, during flowering on velocity and direction of wind. This was done in view of finding out a distance at which maximum out crossing will take place by providing most conductive conditions for the out crossing. It was observed that velocity of wind was quite high from May 2000 to July 2000 as compare to August to September 2000 during which weather was reported to be calm. Direction of wind remained predominately southeast (SE), facilitating the traveling of pollen from contaminator plot and pollen parent to seed parent, resulting in high fruit setting. Murthy and Murthy (1968) reported that velocity and direction of wind was major contributor to natural crossing. Wind direction was reported to have a considerable impact on the pollen dispersal of chilli (Singh et al 1973), as degree of out crossing was markedly higher in plants, planted towards the southeastern side of the marker plot. (Singh and Singh 1978) also found that extent of out crossing may vary from season to season and place to place depending upon wind velocity and prevailing climatic conditions. Gaddagimath (1998) observed higher out crossing in east, sortheast and southeast direction of marker plot, attributing to role played by wind under Karnataka conditions.

The significant difference observed in fruit number per plant under different harvesting may be due to different climatic conditions, pollinator activities and status of plant health. The significantly lesfruit number in first harvesting may be due to detrimental effect of high temperature (39.40^0 C) and low relative humidity (44%) at the time of fruit setting, whereas, reduction in fourth harvesting was the results of decline in plant health and significant fall in night temperature. Gill and Gill (1995) also reported that almost negligible fruit set was observed during the months of May and June because of very high temperature (36-42^0 C) and low relative humidity (35% or lower) which might have proved detrimental to the pollen viability and restricted the number of pollinating agents and their activity.

Kanwar (1995) also opined that insects seem to play major role in out crossing under Punjab conditions as the cross pollination was recorded to be high in second harvesting (13.95%) than first (11.57%), which was attributed to the insect population due to prevailing favorable weather conditions for them.

The insects were observed to be higher in number during flowering period facilitating pollination process. The activity was noted to be highest from 8 a.m. till 11 a.m. Singh et al (1973) also observed that among the insects visiting the crop, *Dipterous* flies were common, while yellow wasps, brinjal hadda and house flies were not regular visitors. Amoak and Yobaoh-Gyan (1991) observed that 75% flowers set fruits in which honey bes served as pollinators as compared to flowers which were compared to flowers which were protected from insects and only 50% flowers set fruits at Ghana.

Ahmed and Tanki (1994) also found that bees, flies and sasps were chief pollinating agents in chilli.

A distinct pattern was observed in percentage out crossing in different MHSPPs, as the distance was increased between the contaminator plot and MHSPP, there was a significant decrease in the percentage out crossing and at one plot it reached at zero. This indicates that the contaminator pollen can travel only up to a certain distance under the influence of wind and pollinator activities. Therefore, on the basis of extent of out crossing at a particular distance from contaminator we can determine the required isolation distance for the crop.

The extent of out crossing among plants of an open pollinated variety, spaced at various isolation distance from contaminator was also compared by Singh et al (1973). It was reported that maximum out crossing (39-45%) was recorded at a distance of 3 m and it decreases to 4.2% at 22.5m. However, Kanwar (1999) reported 8.8% out crossing in an open pollinated variety at a distance of 5 m from the market plot, which was declined to 1.8% at an isolation distance of 180 m. No contamination was recorded beyond 200 m. Under, Karnataka conditions 9-10% out crossing has been reported by Gaddagimath (1998) at a distance of 120 m and an isolation distance of 250 m was suggested to be safe for the maintenance of varietal purity in open pollinated varieties. Ahmed and Tanki (1994) recorded 1.19, 0.14 and 0.00% contamination under Kashmir conditions at a distance of 200 m, 400 m and 600 m, respectively. Therefore, they suggested, that for the production of foundation seed or certified seed, a minimum isolation distance of 400 m should be kept between two varieties while for production of breeder seed it should be 600 m. In second and third harvesting more out crossing was recorded because of favorable weather conditions as compare to first and fourth harvesting.

The overall evaluation indicated that at 200 m distance from contaminator, a negligible amount of out crossing was recorded and it was zero at 225 m and beyond this. Therefore, a minimum isolation distance of 225 m is safe for the production of pure hybrid seed under North Indian conditions. The seeds obtained from third and fourth pickings have maximum genetic purity maximum purity as compare to first and second harvesting.

The overall evaluation indicated that at 200 m distance from contaminator, a negligible amount of out crossing was recorded and it was zero at 225 m and beyond this. Therefore, a minimum isolation distance of 225 m is safe for the production of pure hybrid seed under. North Indian conditions. The seeds obtained from third and fourth pickings have maximum genetic purity maximum purity as compare to first and second harvesting.

The results of experiment have the practical importance and implication in hybrid seed production technology. Infect, the maximum isolation requirements for any crop assure approximately 100% genetic purity which is a prerequisite for quality seed. Further studies are underway to standardize the minimum isolation distance for hybrid seed production of chilli.

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TOTAL PRODUCTIVITY, SUSTAINABILITY AND RECOVERY OF P AND S BY GROUNDNUT-SUNFLOWER INTERCROPPING WITH SIMULTANEOUS AND STAGGERED PLANTING IN RELATION TO P AND S FERTILIZATION

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ABSTRACT

A field experiment was conducted at New Delhi during Kharif seasons of 1999 and 2000. Sole groundnut system was found to record the highest productivity (30.1 q ha^{-1}), and benefit-cost ratio (2.08). The system was also evaluated to be most sustainable over intercropping systems. The highest productivity over the systems as well as net returns and benefit-cost ratio and total uptake of P and S were recorded with the application f 40 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} for respective nutrients. Groundnut with simultaneous sown sunflower removed highest among of P as well S from the soil. The simultaneous sown intercropping system recorded maximum apparent recovery of P, while the highest apparent recovery of S and highest agronomic efficiency of both P and S were registered with sole groundnut system. Both apparent recovery and agronomic efficiency for P as well as S were low at the highest level of the nutrient use.

Key words : Groundnut, sunflower, phosphorus, sulphur, apparent recovery, agronomic efficiency, sustainability.

India has made significant stride in the production scenario of cereals. But oilseed crops remain to be major concern with their stagnating yields and falling production due to shrinkage in area under cultivation. Groundnut-sunflower intercropping provides an opportunity to maximize the production of edible oil per unit land in traditional groundnut growing areas. However, growing of sunflower as an intercrop with groundnut invariably affects growth and yield of groundnut adversely possibly because of shading effect and/or allelopathic effect of sunflower. Delaying the sowing of sunflower by one month may provide a competition free period of about two months to groundnut and thereby minimizing the adverse effects of sunflower on groundnut. One of the main reasons for low productivity of oilseeds is that these energy rich crops are grown under energy starved condition. The productivity of these crops can be increased substantially with proper nutrient management. Since, managing nutrients for the component crops separately in an intercropping system is practically a difficult option, a system based approach to evaluate the nutrient requirements for the system as a whole draws attention. Besides nitrogen, evaluation of phosphorus and sulphur requirements of the system is the need of the hour, since both the nutrients play significant role in improving oil yield of both the crops. Keeping this fact in view, an experiment was planned to study the performance of groundnut-sunflower intercropping and simultaneous and staggered planting in relation to P and S fertilization.

MATERIALS AND METHODS

The field experiment was conducted at Indian Agricltural Research Institute, New Delhi during kharif season of 1999 and 2000. The experiment was laid out in split-plot design with three replications. Three cropping systems namely 1. Sole groundnut (GN_{sole}), 2. Groundnut intercropped with simultaneously sown sunflower sown one month late ($GN+SF_{stag.}$). In both the intercropping systems groundnut and sunflower were sown in 2:1 row ratio in replacement series with the row spacing of 33.3 cm with 67 and 50 percent sole stand of groundnut and sunflower respectively. Combinations of three levels each of P (0, 40 and 80 kg P_2O_5 ha^{-1}) and S (0, 30 and 60 kg S ha^{-1}) formed the sub-plot treatments. P and S were applied through DAP (46% P_2O_5 and 18% N) and gypsum (Agricultural grade containing 18.6% S), respectively. Required proportions of urea (45.6% N) were added to different treatments to make up N dose of 30 kg ha-1 was done to sunflower rows only at 30 days after sowing. The soil of the experimental site was sandy-loam in texture, analyzed low in available nitrogen (132.4 kg N ha^{-1}), medium in available phosphorus (48.1 kg P_2O_5 ha^{-1}), available sulphur (48.2 kg SO_4-S ha^{-1}) and available potassium (292 kg K_2O ha^{-1}) with pH 7.3. The groundnut variety SG-84 (semi-spreading Spanish type and sunflower hybrid MSFH-8 were used as test crops. The total productivity of the systems were expressed as groundnut equivalent yield. The total oil yield and uptake of P and S were recorded as the summation of respective values for two component crops. Apparent recovery of the nutrient was calculated as the per cent recovery of the added nutrient over control while the agronomic efficiently indicated the kg yield per kg added nutrient over control. Economics of the treatments had been computed based on the prevailing market price for the inputs and products. The formula used for the calculation of sustainable yield index (SYI) was given by Singh et al. (1990).

RESULTS AND DISCUSSION

Total productivity

Highest total productivity recorded from the sole groundnut system remained statistically on par with that of intercropping systems (Table 1). This was because the productivity of sunflower was too low to compensate the loss of groundnut yield due to replacement of 33 per cent density.

The application of 40 kg P_2O_5 ha^{-1} resulted the highest total productivity over the systems with an increase of 27 percent over control (Table 1). The total productivity of 80 kg P_2O_5 ha^{-1} though declined sharply was also significantly higher than control. Higher seed yield of fun-flower at 80 kgs P_2O_5 ha^{-1} could not compensate the decline in pod yield of groundnut at this level of P application.

Table 1. Total productivity and oil yields over the systems as influenced by groundnut-sunflower intercropping and levels of P and S (pooled over two years)

Treatment	Pod/seed yield (qQ/h^{-1})			Oil yield (qQ/ha^{-1})		
	Groundnut	Sunflower	Total (groundnut eq.)	Groundnut	Sunflower	Total
Cropping system						
GN$_{sole}$	30.1	–	30.1	11.7	–	11.7
GH+SF$_{simul.}$	23.0	5.0	28.1	8.7	1.78	10.4
GN+Sf$_{stag.}$	25.4	2.4	27.8	9.8	0.76	10.5
SEm(±)	**0.7**	**0.1**	**0.8**	**0.4**	**0.06**	**0.3**
C.D. (0.05)	**2.9**	**06**	**NS**	**1.4**	**0.32**	**1.2**
Levels of P$_2$O$_5$(kg ha^{-1})						
0	22.9	3.1	25.0	8.0	1.03	8.7
40	29.3	3.9	31.9	11.7	1.33	12.6
80	26.3	4.1	29.1	10.5	1.46	11.5
SEm (±)	**0.6**	**0.1**	**0.6**	**0.3**	**0.05**	**0.3**
C.D. (0.05)	**1.8**	**0.2**	**1.8**	**0.9**	**0.13**	**0.7**
Levels of S (kg ha^{-1})						
0	22.9	3.3	25.1	7.9	1.13	8.6
30	29.1	3.9	31.7	11.7	1.31	12.6
60	26.5	4.0	29.1	10.6	1.37	11.5
SEm(±)	**0.6**	**0.1**	**0.6**	**0.3**	**0.05**	**0.3**
C.D. (0.05)	**1.8**	**0.2**	**1.8**	**0.9**	**0.13**	**0.7**

As regards effect of S application, the highest total productivity with an increase of 26 percent over control was recorded at 30 kg S ha^{-1}. This was because of highest productivity of groundnut and sunflower at this level of S application.

Total oil yield

The sole groundnut recorded significantly higher oil yield over intercropping system. Whereas total oil yield from intercropping systems remained statistically on par (Table 1).

The application of 40 kg P_2O_5 ha^{-1} recorded the highest total oil yield. This was significantly higher than both 0 and 80 kg P_2O_5 ha^{-1}.

As regards the influence of sulphur, the highest oil yield was registered with 30 kg S ha^{-1}. Application of 30 kg S ha^{-1} increased the oil yield of intercropping system by 46 percent over control.

Economics and sustainability

A close analysis of the data presented in Table 2 revealed that sole groundnut system earned the highest net returns (Rs. 28687) and benefit : cost ratio (2.08). These returns were suppressed due to intercropping, whereas both the intercropping systems remained on par. This observation is in agreement with the findings of Mohammad et al. (1992).

Among the levels of P_2O_5, 40 kg dose gave the highest net return of Rs. 30899 and benefit : cost ratio 2.24. Similarly, 30 kg S ha^{-1} recorded the highest net return of Rs. 30628 and the benefit : cost ratio of 2.22. The highest total productivity at 40 kg P_2O_5 and 30 kg S ha^{-1} led to record highest net return as well as benefit : cost ratio at these levels of nutrients application.

Sole groundnut system could be inferred as most sustainable on the basis of sustainable yield index (SYI) as indicated from the data (Table 2). SYI value was highest when no P was used. But application of S at 30 kg ha^{-1} recorded the highest SYI value.

Total Uptake, Apparent Recovery And Agronomic Efficiency of Phosphorus

The total uptake, apparent recovery and agronomic efficiency of phosphorus were significantly governed by the cropping systems and levels of p and s (Table 3). The intercropping system with simultaneous sown sunflower recorded the highest total uptake and apparent recovery of P. From this observation it should be inferred that there might have been no competition for P in the intercropping system. Since, groundnut has the inherent capacity to solubilize sparingly soluble P in soil (Ae and Otani, 1997), thereby avoiding a competition for this nutrient. The sole groundnut system recorded the highest agronomic efficiency for P use owing to its highest total productivity.

The highest total uptake of P over the systems was recorded at 40 kg P_2O_5 ha^{-1}. Apparent recovery of P was sharply declined with the increasing level of P application. This observation was in confirmation with the findings of Aulakh and Pasricha (1996). Lower total productivity over the systems at the highest level of P led to record a low agronomic efficiency.

Table 2. Total cost, gross return, net return, benefit/cost (B/C) ratio and sustainable yield index (SYI) as affected by groundnut-sunflower intercropping and levels of P and S

Treatment	Mean of two years data				
	Total cost (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B/C ratio	SYI
Cropping System					
GN_{sole}	13744	42432	28687	2.08	0.85
$GN + SF_{simul.}$	13835	39205	25370	1.83	0.80
$GN + SF_{stag.}$	13835	39281	25446	1.84	0.83
P levels (kg $P_2O_5ha^{-1}$)					
0	13168	35365	22198	1.68	0.84
40	13805	44704	30899	2.24	0.82
80	14442	40848	26406	1.83	0.82
S levels (kg S ha^{-1})					
0	13443	35490	22047	1.63	0.83
30	13805	44433	30628	2.22	0.84
60	14167	40995	26828	1.90	0.81

Application of S increased the total uptake of P over the system with up to 30 kg S ha^{-1} but caused significant decline at 60 kg S ha^{-1} level. Apparent recovery as well as agronomic efficiency of P were higher at 0 and 30 kg S ha^{-1} levels. But sharp decline in these parameters was observed at the highest level of S application. Decline in total uptake of P as well as total productivity over the system was the direct cause for such observation.

Total uptake, apparent recovery and agronomic efficiency of sulphur were significantly influenced by intercropping of sunflower in groundnut with simultaneous and staggered sowing and levels of P and S application as well (Table 3). Intercropping system with simultaneous sown sunflower recorded the highest S uptake but apparent recovery os S was highest with sole groundnut system. From this observation, it could be inferred that there might have competition for S among two oilseeds crops in intercropping. Since the total productivity was highest with sole groundnut system, it recorded the highest agronomic efficiency of S use.

Total uptake of S was increased with the application of P_2O_5 up to 40 kg ha^{-1}. Apparent recovery as well as agronomic

Table 3. Total uptake, apparent recovery and agronomic efficiency of P and S over the systems as influenced by groundnut-sunflower intercropping and levels of P and S (pooled over two years)

Treatment	Phosphorus			Sulphur		
	Total uptake (kg P ha^{-1})	Apparent recovery (%)	Agronomic efficiency (kg/kg P_2O_5)	Total uptake (kg S ha^{-1})	Apparent recovery (%)	Agronomic efficiency (kg/kg S)
Cropping system						
GN$_{sole}$	14.2	27.0	16.1	23.3	17.2	21.4
GH+SF$_{simul.}$	22.8	48.0	9.1	28.1	13.0	15.8
GN+SF$_{stag.}$	16.5	26.3	11.4	25.0	12.6	13.2
SEm(±)	0.3	0.6	1.3	0.5	1.0	1.4
CD (0.05)	1.2	2.5	5.2	1.9	3.7	5.5
Levels of P_2O_5 (kg ha^{-1})						
0	12.9	–	–	21.1	18.3	21.0
40	21.8	50.6	18.1	28.9	19.4	27.0
80	18.8	17.1	6.2	26.3	5.1	2.3
SEm (±)	0.2	0.6	1.4	0.4	1.6	1.3
CD (0.05)	0.7	1.7	4.1	1.0	4.7	3.6
Levels of S (kg ha^{-1})						
0	15.4	38.0	15.2	22.0	–	–
30	20.0	37.5	17.1	28.2	21.1	24.8
60	18.1	26.0	4.3	26.1	7.4	8.8
SEm(±)	**0.2**	**0.7**	**1.8**	**0.4**	**1.3**	**0.9**
CD (0.05)	**0.7**	**2.1**	**5.0**	**1.0**	**3.6**	**2.6**

efficiency of S remained high at 0 and 40 kg P_2O_5 ha^{-1} levels but declined drastically at the highest level of P application. This was because of low uptake and total productivity at this level of P use.

Total uptake of S over the systems was highest at 30 kg S ha^{-1} and significantly declined at 60 kg S ha^{-1}. the highest apparent recovery and agronomic efficiency of S were recorded at 30 kg S ha^{-1} but declined sharply at 60 kg S ha^{-1}. This was due to lower uptake and total productivity at this level of S application.

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EFFECT OF DOSE AND APPLICATION METHODS OF DIFFERENT UREA BASED FERTILIZERS ON YIELD OF LOWLAND RICE

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Abstract

A field experiment was conducted during Kharif seasons of 1996 and 1998 on a fine loamy mixed hyperthermic Epiaquept of the Central Farm of Orissa University of Agriculture and Technology, Bhubaneshwar to study the efficiency of nimin coated prilled urea and Urea Super Granule (USG) at variable doses of nitrogen and application methods on the growth and yield of lowland rice (cv. Lalat). The results indicated that deep placement of USG@ 76kg N ha^{-1} at 5 cm soil depth produced significantly higher grain (43.1 q/ha^{-1}) and straw (47.8 q ha^{-1}) with highest NUE (24.3). Although, nimin coated prilled urea influenced the yield to a lesser extent as compared to USG, it produced significantly higher grain and straw yield over prilled urea (PU) alone. The study suggests that 76kg N ha^{-1} is the optimum dose of N as USG and nimin coated prilled urea application in rice and 5 cm is the ideal placement depth for USG.

Key words : Deep placement, urea super granule, nimin coated prilled urea, nitrogen use efficiency, rice.

The efficiency of the applied nitrogen is very low in the lowland rice fields which seldom exceeds 60-65% with best agronomic practices and strictly controlled conditions (De Datta *et al.* 1968). Broadcasting, a common method for application of Prilled Urea (PU) accounts for lower efficiency due to loss of N through leaching, runoff, volatilization, denitrification and biodegradation. However, modification of size and method of application of PU proved to be beneficial under this situation. Pandey et al (1989) reported that the nitrogen applied through Urea Super Granule (USG) was more efficient than split application of Prilled Urea (PU). The superiority of deep placement of USG over broadcasting of USG or PU in increasing the yield of lowland rice was reported by several workers (Tandon, 1989; Dupy, 1990 and Mishra *et al.*, 1999).

Further, coating of PU with nimin, containing nitrification inhibitors helped to increase efficiency of applied N(Vyas et al, 1991) and resulted in higher grain and straw yield than PU application alone. The information on dose and method of application of nimin coated PU and USG for lowland rice is very meagre in Orissa situation. Therefore, the present investigation was aimed to find out the dose and method of application of USG, nimin coated PU in lowland rice.

MATERIALS AND METHODS

A field experiment was carried out at Central Farm of Orissa University of Agriculture and Technology, Bhubaneswar during Kharif seasons of 1996 and 1998 so as to evaluate the dose and method of application of different forms of urea based fertilizers in lowland rice. The soil of the experimental site was sandy loam in texture (76% sand, 12% silt and 12% Clay) with pH 6.1, organic carbon 2.6 g kg^{-1} and available N, P and K of 201, 18 and 188 kg ha^{-1} respectively. The experiment consisted of ten treatments, each replicated thrice in a randomized block design. The treatments in both the years were as follows :

T_1 – Control (without nitrogenous fertilizer)

T_2 – Broadcasting of PU @ 76 kg N ha^{-1} in 3 splits (1:2:1)

T_3 – Broadcasting of PU @ 76 kg N ha^{-1} with nimin (1%), all applied as basal.

T_4 – Broadcasting of PU @ 76 kg N ha^{-1} in 3 splits (1:2:1), out of which first two splits were applied with nimin (1%) and the last split without nimin.

T_5 – Broadcasting of PU @ 95 kg N ha^{-1} with nimin (1%), all applied as basal.

T_6 – Broadcasting of PU @ 95 kg N ha^{-1} in 3 splits (1:2:1), out of which first two splits were applied with nimin and the last split without nimin.

T_7 – Deep placement of USG @ 76 kg N ha^{-1} at 5 cm soil depth.

T_8 – Deep placement of USG @ 76 kg N ha^{-1} at 7.5 cm soil depth.

T_9 – Deep placement of USG @ 95 kg N ha^{-1} at 5 cm soil depth.

T_{10} – Deep placement of USG @ 95 kg N ha^{-1} at 7.5 cm soil depth.

Rice seedings (cv-Lalat) of 30 days old were transplanted in the experimental plot of size 4 m × 3 m on the 4th August in the first year (1996) and on 3rd August in the second year (1998). A spacing of 20 cm × 15 cm was followed for treatment plots T_1 to T_6 whereas an alternate row spacing of 15 cm and 25 cm and a plant spacing of 15 cm was followed in treatment of plots of T_7 to T_{10} according to IFDC design. These two types of spacings had maintained a plant population of 33 hills m^{-2} and alternate line spacing of 25 cm served as traffic line for manual placement of USG in the field. A common dose of 50 kg each of P_2O_5 and K_2O per hectare as single super phosphate and muriate of potash respectively was applied as basal. The PU was applied in 3 splits i.e. at transplanting, tillering and at panicle initiation stage whereas USG (1g size) was point placed in the centre of four rice hills after 7 days of transplanting manually. The nimin was supplied by Godrej Agrovet Ltd. in the liquid form. Plant protection measures were taken as and when necessary. Ten plants were selected randomnly from each plot at the time of harvest and the yield attributing characters like plant height, panicle length, number of effective tillers per hill etc. were studied. The grain and straw yields of rice were recorded at harvest.

RESULTS AND DISCUSSION

Grain and straw yields

The grain and straw yields of rice under different treatments for both the years were presented in table-1. During 1996, the grain yield varied from 23.7 to 41.6 q ha^{-1} and the straw yield from 26.7 to 48.4 q ha^{-1} whereas the range of variation during 1998 was 25.6 to 44.5 q ha^{-1} and 28.7 to 48.4 q ha^{-1} for grain and straw yield respectively. The difference in grain and straw yields over the years may be attributed due to variation in rainfall pattern. Nitrogen applied @ 76 kg and 95 kg ha^{-1} (T_2 to T_{10}) produced significantly higher grain and straw yield over control (T_1). This indicated that the application of nitrogen helped in increasing the grain and straw yield of rice. It was also observed that when full dose of nitrogen was applied as basal in form of PU @ 76 kg N ha^{-1} with nimin (T_3), the grain and straw yield was significantly increased as against the application of only PU @ 76 kg N ha^{-1} (T_2) in three splits. This findings corroborates the results of Vyas et al (1991). The higher yield may be attributed to the fact that nimin coated PU when applied in soil, a part of the NH_2-N was displaced downward due to its low hydrolysis unlike that of the PU applied without nimin. The NH_2-N so displaced was hydrolysed to NH_4^+-N in the reduced zone of the soil and retained in the soil comparatively for a longer period in presence of nitrification inhibitor in nimin. Thus, the availability of nitrogen to the crop for a longer period in case of nimin coated PU might have increased the grain and straw yield was marginally increased over T_3, when PU with nimin was applied in splits (T_4). This showed that split application of nimin coated PU appeared to be more effective as compared to one time application at planting. Deep placement of USG significantly increased the grain and straw yield of rice as compared to split application of PU (T_2). Further, the mean grain and straw yield of rice was significantly more in case of USG placement at 5 cm soil depth @ 76 kg N ha^{-1} (T_7) than that obtained in case of PU with nimin (1%) applied as basal at the same dose (T_3). Thus, there was an extra advantage both in grain and straw yields of rice when USG was deep placed in soil. Since USG was placed in reduced zone of soil, NH_4^+-N so formed could not be nitrified, unlike that resulted in case of PU or nimin coated PU. As a result, the availability of N to the crop was more in case of USG as compared to PU or nimin coated PU. It has also been observed that the grain yield of rice was more for nitrogen application @ 76 kg N ha^{-1} than that recorded at 95 kg N ha^{-1} for USG. The deep placement of USG at 7.5 cm proved to be less effective than placement of USG at 5 cm depth because, NH_4^+-N so formed perhaps quickly leached down below the root zone of the rice plant. This result corroborate with the results of Mitra et al (1989) and Mishara et al. (1999). considering the above facts USG should be deep placed at 5 cm soil depth @ 76 kg N ha^{-1} to get optimum benefit from rice.

Nitrogen Use Efficiency (NUE)

The data on NUE i.e. kg grain yield per kg of applied nitrogen of various treatments (Table-1) varied from 9.5 to 24.9 in both the years. Highest value of NUE was recorded in the treatment (T_7) receivig 76 kg N ha^{-1} in form of USG with a placement depth of 5 cm and the lowest in the treatment (T_2) receiving PU alone at the same dose. Irrespective of sources, with increase in dose of nitrogen there was decrease in its use efficiency by the crop. The efficiency was higher when PU coated with nimin (1%)

Table 1. Grain and straw yield, NUE of rice (Cv Lalat) as influenced by different treatments

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			NUE (kg grain/ kg N applied)		
	1996	1998	Pooled Mean	1996	1998	Pooled Mean	1996	1998	Mean
T_1	23.7	25.6	24.7	26.7	28.7	27.7	–	–	–
T_2	30.9	33.6	32.3	33.6	36.6	35.1	9.5	10.5	10.0
T_3	36.2	36.8	36.5	40.0	39.7	39.9	16.4	14.7	15.6
T_4	37.1	37.9	37.5	43.6	40.7	42.2	17.6	16.2	16.9
T_5	34.0	35.9	35.0	37.8	40.4	39.1	10.8	10.8	10.8
T_6	37.4	39.2	38.3	44.7	42.6	43.7	14.4	14.3	14.4
T_7	41.6	44.5	43.1	47.1	48.4	47.8	23.6	24.9	24.3
T_8	37.6	43.2	40.4	41.0	47.5	44.3	18.3	23.2	20.8
T_9	37.9	39.8	38.9	41.3	43.8	42.6	14.9	14.9	14.9
T_{10}	33.2	37.8	35.5	37.3	42.1	39.7	10.0	12.8	11.4
C.D. at 5%	3.59	4.13	2.55	4.67	3.91	3.20			
CV (%)	5.99	6.43	6.06	6.93	5.56	6.84			

was applied @ 76 kg N ha^{-1} than its sole application without nimin. The NUE was comparatively better in USG than nimin coated PU at both the doses of nitrogen. Deep placement of USG at a depth of 5 cm was found to be better than 7.5 cm depth.

Growth parameters of rice

The growth parameters of rice like plant height, panicle length and number of effective tillers per hill under different treatments for both the years are presented in Table-1.

The mean plant height varied from 83.6 cm to 97.6 cm. It was minimum when no nitrogen was applied (T_1), but increased to a maximum value when USG was applied @ 76 kg N ha^{-1} (T_7). Applcation of nitrogen significantly increased the plant height, particularly in case of PU application. Although application of nimin as nitrification inhibitor increased the plant height, its effect was not significant as compared to split application without nimin. On the other hand, placement of USG significantly increased the plant height as compared to PU application without nimin. In case of USG, the plant height was longer when USG was applied @ 76 kg N ha^{-1} at 5 cm depth than that applied at 7.5 cm soil depth.

The panicle length varied from 21.7 cm to 25.8 cm in various treatments over the years. It was shortest (21.7 cm) when no nitrogen was applied to the crop. Application of nitrogen significantly increased the panicle length of the crop both in case of PU and USG. Further, it was recorded that panicle length of the crop was longer in case of USG placement than in case of PU possibly slow release of nitrogen from USG helped to produce longer panicle length for which the grain yield of rice was correspondingly increased (Table - 2) in USG treatments.

The number of effective tillers per hill varied from 5.9 to 10.4 (Table-2) under different treatments, but there was no significant difference in these values in both the years. However, minimum effective tillers were six when no nitrogen was applied (T_1). application of PU in split (T_2) increased the tiller number to seven. But, when the same fertilizer was blended with nimin (T_3, T_4, T_5 and T_6) the tiller number was further increased to 8 or 9. The tiller number was further increased to ten (T_7 and T_9) when USG was deep placed at 5 cm soil depth at both the doses.

From the results of the present investigation, it was inferred that deep placement of USG @ 76 kg N ha^{-1} at 5 cm soil depth produced highest grain and straw yields of rie with better NUE. The growth parameters were also much influenced by this treatment. Also, nimin coated prilled urea @ 76 kg N ha^{-1} in splits would found to be better than PU application without nimin.

Table 2. Growth parameters of rice (cv Lalat) as influenced by dCifferent treatments

Treatments	Plant height (cm)			Panicle length (cm)			Effective tillers per hill		
	1996	1998	Mean	1996	1998	Mean	1996	1998	Mean
T_1	83.1	84.0	83.6	21.0	21.7	21.4	5.9	6.3	6.1
T_2	83.4	84.5	84.0	21.9	23.0	22.5	6.7	7.3	7.0
T_3	83.4	85.7	84.6	21.6	22.6	22.1	8.3	8.7	8.5
T_4	89.0	91.1	90.1	23.9	24.7	24.3	8.8	9.3	9.1
T_5	90.4	92.0	91.2	23.7	24.4	24.1	9.5	9.9	9.7
T_6	95.3	96.3	95.8	24.2	25.2	24.8	9.5	9.7	9.6
T_7	97.3	97.9	97.6	25.0	25.8	25.4	10.1	10.4	10.3
T_8	93.2	95.6	94.4	24.3	25.2	24.8	9.6	10.1	9.9
T_9	94.5	96.1	95.3	23.3	24.5	23.9	9.7	10.2	10.0
T_{10}	91.7	93.2	92.5	22.4	24.0	23.2	8.4	8.0	8.2
CD at 5%	4.71	4.55		1.98	2.15		NS	NS	
CV (%)	3.05	2.89		4.99	5.20		2.03	2.63	

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PROFILE DISTRIBUTION OF BORON FORMS IN RELATION TO SOIL CHARACTERISTICS IN ARID SOILS OF WESTERN RAJASTHAN

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ABSTRACT

In five soil profiles of western Rajasthan, distribution of available boron (B) and different fractions of B were evaluated and correlated with soil characteristics. The following B fractions were determined : (i) readily soluble B, (ii) secifically adsorbed B, (iii) oxide-bound B, (iv) organically-bound B, (v) residual B, and (vi) total B. The available B varied from 0.40 to 3.70 mg kg^{-1}, with a mean value of 1.52 mg kg^{-1}. In these soils, the range of different B fraction was found as follow : 0.12-12.7 mg kg^{-1} readily soluble B, 0.10-1.27 mg kg^{-1} specifically adsorbed B, 0.22-0.66 mg kg^{-1} oxide-bound B, 0.46-1.70 mg kg^{-1} organically-bound B, 15.29-25.05 mg kg^{-1} residual B, and 19.24-26.31 mg kg^{-1} total B. The major portion of soil B existed in residual form. The available B was positively and significantly correlated with pH, EC, organic carbon and CEC of soil. The soil characteristics that influenced the different forms of soil B were pH, EC, organic carbon, CEC, free Al+Fe oxides and silt-clay contents. Highly significant correlations were observed between these soil characteristics and some of the soil B fractions.

Key words : Boron forms, fractionation, soil characteristics, arid soil profile, Rajasthan.

Knowledge of elemental distribution in different fractions of boron (B) in soils is essential for the proper management of soils with regard to its deficiency or toxicity. Higher concentration of B may be present in arid and semi-arid soils or developed as a consequence of long-term use of irrigation water containing fairly high proportion of B (Evans and Sparks, 1983). Earlier work was mainly carried out on the available B content in the surface soils of Rajasthan. Distribution of various forms of B is greatly influenced by soil characteristics. The studies on the different forms of B, and their relationships with soil characteristics, are important for efficient utilization of native and applied B. Hence, the present study was planned to evaluate the depthwise distribution of different forms of B and their relationships with soil properties in arid soils of western Rajasthan.

MATERIALS AND METHODS

In all seventeen soil samples were collected depth wise from five soil profiles representing major soil great groups of arid soils western Rajasthan in the month of June, 2001. The samples were analyzed for pH, EC, organic carbon (OC), CEC, free $CaCO_3$, free Al+Fe oxides, sand, silt and clay by adopting standard procedures. Some of their important physical and chemical characteristics are listed in Table 1. The available B was extracted by hot 0.01 M $CaCl_2$ (Aitken *et al.*, 1987) and estimated by azomethine-H (John et al., 1975). All fractions of B, except the residual, were separated by sequential extraction technique that was developed by Hou et al. (1996) and modified by Datta *et al.* (2002) which is depicted in Fig. 1. The residual fraction was calculated by subtracting above four fractions from the corresponding total fraction. Total B in soil samples was extracted above four fractions from the corresponding total fraction. Total B in soil samples was extracted by digestion of soils in H_2SO_4, HF and $HClO_4$ acids (Datta et al., 2002). Boron in the extracts of first two fractions (readily soluble and specifically absorbed) was estimated by azomethine-H (John *et al.*, 1975) and in remaining fractions (oxide-

Table 1. Some important characteristics of soil profile

Depth (cm)	pH	EC (dS m^{-1})	OC (%)	$CaCO_3$ (%)	CEC [cmol (p+) kg-1]	Free Al+Fe oxides (mg kg^{-1})	Sand (%)	Silt (%)	Clay (%)
Haplocambid (Manai - Jodhpur)									
00-10	8.73	1.12	0.31	0.25	5.21	1285.38	60.5	9.2	30.3
10-20	9.49	0.82	0.20	0.25	6.65	1010.65	70.3	9.0	20.7
20-40	9.60	0.92	0.20	0.50	9.96	832.82	68.7	8.1	23.2
Haplocambid (Narwa-Jodhpur)									
00-10	8.70	0.44	0.28	2.00	4.57	1463.87	76.7	7.4	15.9
10-20	8.92	0.40	0.25	1.00	5.25	1191.24	77.8	4.6	17.6
20-40	8.86	0.42	0.25	2.50	6.95	1106.24	69.2	9.2	21.6
Petrogypsid (Kawas - Barmer)									
0-10	8.02	0.29	0.20	8.00	5.00	531.98	58.0	13.2	28.8
10-30	8.00	0.41	0.19	11.00	5.65	660.00	54.5	13.5	32.0
30-50	8.02	0.34	0.23	15.00	5.87	588.41	53.0	14.7	32.3
50-70	8.00	0.34	0.20	16.50	5.65	769.21	54.5	16.0	29.5
Haplogypsid (Rawatsar - Hanumangarh)									
0-20	9.12	0.85	0.23	7.25	7.31	812.92	57.2	24.2	18.6
20-45	8.93	4.04	0.31	18.50	15.57	527.55	40.8	30.0	29.2
45-85	8.84	0.98	0.22	20.50	14.78	381.39	44.7	21.1	34.2
85-110	9.64	0.87	0.22	5.50	9.18	1,041.55	72.8	9.9	17.3
Haplosalid (Rohit - Pali)									
00-10	9.36	1.47	0.39	1.50	11.31	935.18	50.7	22.1	27.2
10-20	9.34	1.59	0.40	2.00	14.35	924.56	48.6	22.2	29.2
20-40	9.23	1.47	0.36	0.50	16.31	1,137.33	46.8	20.3	32.9

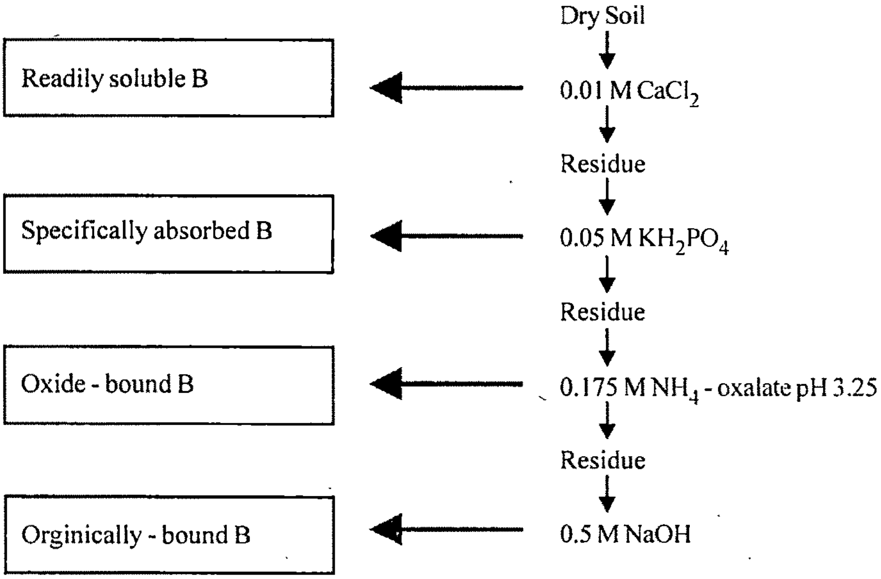

Fig. 1. Flow sheet of extraction of different fractions of boron in soils.

bound, organically-bound and total) was estimated by carmine method (Hatcher and Wilcox, 1950). Simple correlations and multiple regression analyses were worked out by standard statistical methods.

RESULTS AND DISCUSSION

Available boron

In profile samples the available B concentration ranged from 0.40 to 3.70 mg kg^{-1}, with a mean value of 1.52 mg kg^{-1} (Table 2). In general, the available B was lower in Petrogypsid great group as compared with other great group soils. The available B in profiles from Manai and Narwa village showed a tendency of increasing with depth, while other profiles showed irregular distribution pattern, depending upon effective depth of leaching. The available B constituted, on an average, 6.27 per cent of the total B in soil. There was significant and positive relationship of available B withpH, EC, OC and CEC of soils (Table 3). This suggests that available B concentration of soils increased during the process of soil salinization/ sodification (Sharma and Bajwa, 1989). A significant positive correlation between organic carbon and availabe B has been reported in calcareous soil of Bihar (Sakal et al. 1993), which may be attributed to the formation of soluble boron-organic complex. Association of B with organic matter prevents its leaching and results in its accumulation in soil surface. In present study, organic carbon alone accounted for 67.46 per cent variation in available B, which is evident from the results of multiple regression analysis (Table 4). Inclusion of pH as another variable improved the prediction value to 85.78 per cent, while CEC and EC accounted for about 1 per cent each in varriability of available B. Available B was significantly and positively correlated

Table 2. Distribution of available boron (mg kg^{-1}) and its different fractions (mg kg^{-1}) in soil profiles of western Rajasthan

Depth (cm)	Available B	Readily Soluble B	Specificall –y adsorbed B	Oxide-bound B	Organicall y– bound B	Residual B	Total B
Haplocambid (Manai-Jodhpur)							
00-10	1.38	0.42	0.53	0.57	1.30	22.48	25.04
10-20	1.70	0.48	0.47	0.42	1.22	20.80	23.33
20-40	1.96	0.62	0.55	0.36	1.16	22.03	24.46
Haplocambid (Narwa-Jodhpur)							
00-10	1.00	0.44	0.32	0.66	1.11	23.58	25.64
10-20	1.19	0.30	0.19	0.53	1.02	21.63	23.43
20-40	1.26	0.37	0.30	0.50	0.78	22.22	23.94
Petrogypsid (Kawas - Barmer)							
0-10	0.82	0.30	0.12	0.23	0.46	24.75	26.31
10-30	0.48	0.16	0.11	0.22	0.66	23.12	24.58
30-50	0.40	0.15	0.14	0.29	0.77	25.05	26.31
50-70	0.47	0.12	0.10	0.30	0.48	24.40	25.65
Haplogypsid (Rawatsar - Hanumangarh)							
0-20	1.25	0.29	0.35	0.31	1.07	23.30	25.34
20-45	2.36	0.75	1.18	0.27	1.70	20.34	23.49
45-85	0.75	0.20	0.73	0.42	0.76	19.93	22.28
85-110	1.43	0.32	0.35	0.66	1.04	22.62	24.75
Haplosalid (Rohit - Pali)							
00-10	2.92	0.97	1.01	0.36	1.04	16.94	20.49
10-20	3.70	1.19	1.16	0.27	1.29	23.37	27.24
20-40	2.70	1.27	1.27	0.29	1.19	15.29	19.24
Range	0.40-3.70	0.12-1.27	0.10-1.27	0.22-0.66	0.46-1.70	15.29-25.05	19.24-26.31
Mean	1.52	0.49	0.52	0.39	1.00	21.85	24.25

with readily soluble, specifically absorbed and organically-bound B (Table 5). Multiple regression equation was developed using availabel B as dependent variable and readily soluble (Res B), specifically absorbed (Sp B), and organically-bound B (Org B) as independent variables.

$$Y = -0.068 + 2.218 \text{ (Res B)} + 0.021 \text{ (Sp B)} + 0.482 \text{ (Org B)}$$

$$R^2 = 0.915^{**}$$

Boron present in soil solution and weakly absorbed by soil components can be considered as a parameter of intensity; B adsorbed specifically on clay surface or associated with organic matter represents the quantity factor of B supplying power of

Table 3. Simple correlation coefficient between available boron and its fraction with soil characteristics

B fraction	pH	EC	OC	CEC	CaCO3	Free Al+Fe oxides	Silt+clay
Readily soluble B	0.571*	0.558*	0.850**	0.685**	-0.449	0.251	0.345
Specifically Absorbed B	0.563*	0.780**	0.802**	0.893**	-0.113	0.004	0.575*
Oxide-bound B	0.345	-0.223	-0.029	-0.28	-0.392	0.702**	-0.720**
Organically-bound B	0.660**	0.767**	0.556*	0.45	-0.305	0.322	0.071
Residual B	-0.427	-0.446	-0.335	-0.460	0.232	-0.141	-0.31
Total B	-0.391	-0.292	-0.329	0.146	-0.460	-0.098	-0.221
Available B	0.697**	0610**	0.821**	0.660**	-0.454	0.217	0.282

***Significant at 5% level, **significant at 1% level.**

Table 4. Effect of soil characteristics on the predictability of available boron and its fractions

FORMS	REGRESSION EQUATION	$R^2 \times 100$
Readily soluble B		
	Y = -0.651+4.34 (OC)	72.28**
	Y = -0.628 + 3.537 (OC) + 0.023 (CEC)	76.82**
	Y = -1.944 + 3.295 (OC) + 0.016 (CEC) + 0.162 (pH)	82.25**
	y = -1.949 + 3.01 (OC) + 0.017 (CEC) + 0.162(pH) - 0.004 (EC)	82.26**
Specifically absorbed B		
	Y = -0.699 + 4.677 (OC)	64.29**
	Y = - 0.636+2.399 (OC) + 0.062 (CEC)	90.48**
	Y = - 0.572 + 2.221 (OC) + 0.048 (CEC) + 0.098 (EC)	92.72**
	Y = -0.484 + 2.176 (OC) + 0.054 (CEC) + 0.103 (EC) - 0.003 (silt + clay)	93.15**
Oxide-bound B		
	Y = 0.087 + $3.40x10^{-4}$ (Al + Fe oxides)	49.27**
	Y = 0.389 + $2.41X10^{-4}$ (Al + Fe oxides) - 8.22×10^{-3} (silt + clay)	57.52**
Organically-bound B		
	Y = -2.286 + + 1.701 (OC)	30.25**
	Y = -2.066+1.681 (OC) + 0.296 (pH)	55.17**
Available B		
	Y = -1.399 + 11.161 (OC)	67.46**
	Y = -7.534 + 8.885 (OC) + 0.759 (pH)	85.78**
	Y = - 7.139 + 7.991 (OC) + 0.713 (pH) + 0.028 (CEC)	86.70**
	Y = -6.966 + 7.758 (OC) + 0.703 (pH) + 0.010 (CEC) + 0.136 (EC)	87.50**

Table 5. Correlation coefficients among different fractions of soil boron and available boron

B Fraction	Readily Soluble B	Specifically adsorbed B	Oxide-bound B	Organically-bound B	Residual B	Total B
Readily soluble B	1.000					
Specifically adsorbed B	0.890**	1.000				
Oxide-bound B	-0.199	-0.202	1.000			
Organically-bound B	0.606**	0.689**	0.027	1.000		
Residual B	-0.656**	-0.734**	-0.01	-0.406	1.00	
Total B	-0.438	0.529*	-0.139	-0.222	0.959**	1.000
Available B	0.948**	0.870**	-0.139	0.680**	-0.567*	-0.329

*Significant at 5% level, ** significant at 1% level.

soils (Jin et al., 1987). Organic matter is also considered as an important source of available B in soils. Based on these analogies, it can be inferred that the hot 0.01 M $CaCl_2$ extractant is capable of extracting B from readily soluble, specifically absorbed, and organically-bound pools. Similar results have also been reported by Datta et al. (2002).

Readily soluble boron : This form f B varied from 0.12 to 1.27 mg kg^{-1}, with a mean value of 0.49 mg kg-1 (Table 2). the distribution of readily soluble B in profiles was similar to available B, which is evident from the correlation study (Table 5) indicating a highly significant correlation (r = 0.948***) between these two. This form of B constituted only 2.02 per cent of the total B. The readily soluble B was significantly and positively correlated with pH, EC, OC and CEC of soils (Table 3). The positive effect of soil pH on readily soluble B is ascribed to the fact that increasing pH increased the negative surface charge of clay and other variable charge surfaces (Hingston et al. 1964). Hou et al (1994) and Datta et al. (2002) observed a significant and positive correlation between readily soluble B and pH of soil. Organic carbon along with CEC, pH and EC could predict 82.26 per cent variation in readily soluble B (Table 4).

Specifically absorbed boron

The specifically absorbed B fraction varied from 0.10 to 1.27 mg kg^{-1}, with a mean value of 0.52 mg kg -1 (Table 2). This form constituted 2.14 per cent of the total B. The distribution pattern of this form of B in profiles showed irregular trend except in the Haplosalid profile, where it was increased with depth. Among the soil properties, this form correlated significantly and positively with pH, EC, OC and CEC of soil (Table 3). Hou et al. (1994) postulated that this fraction includes desorbed B from inorganic constituents such as hydrous oxides through ligand exchange reactions and established a positive and significant relationship of specificaly absorbed B with pH of soil, but a negative and significant relationship with free Al_2O_3. This fraction of B probably originated from week binding sites of both organic and inorganic constituents. Organic carbon and CEC accounted for 90.48 per cent variability in specifically absorbed B (Table 4). These two factors along with EC and silt + clay contents acounted for about 93 percent variation in specifically absorbed B.

Oxide-bound boron

This fraction of B was found lowest as compared with other fractions, and ranged from 0.22 to 0.66 mg kg^{-1}, with a mean value fo 0.39 mg kg^{-1} (Table 2). This form of B formed 1.61 per cent of the total B. The oxide-bound B content increased with depth in two profiles (Manai and Narwa), whereas reverse or irregular trend was observed in rest of profiles. This form was positively and significantly correlated with free Al+Fe oxides content of soils. These results are in conformity with the findings of Hou et al. (1994) and Hou et al. (1996). This property alone was responsible for 49.27 per cent predictability of oxide-bound B. The predictability was found to increase to 57.52 per cent when silt+clay contents were included (Table 4). As NH_4-oxalate can solubilize non-crystalline and crystalline oxy-hydroxides of Fe and Al from soils, the relationship of oxide bound B free with Al and Fe oxides is a logical one as adsorption of both as B $(OH)_3^0$ and $B(OH)_4^-$ species, takes place on Fe_2O_3 via ligand exchange (Su and Suarez, 1995).

Organically-bound boron

The organically-bound B content in soils varied from 0.46 to 1.70 mg kg^{-1}, with a mean value of 1.00 mg kg^{-1} (Table 2). This form constituted 4.12 per cent of total B. The organically-bound B content decreased with depth in two profiles (Manai and Narwa), whereas irregular pattern of distribution was observed in rest of profiles. This fraction significantly and positively correlated with pH, EC and organic OC content of soil (Table 3). Organic carbon and pH could predict 55.17 per cent of variation in organically-bound B (Table-4). It indicates that organic carbon is a major contribution of this fraction. This finding concurred with the result of Hou et al. (1994).

Residual boron

The major portion of B is soils existed as residual or occluded forms. Residual B content in soil varied from 15.29 to 25.05 mg kg^{-1}, with a mean value of 21.85 mg kg^{-1}. Residual form accounted for 82.67 to 95.24 per cent of total B, with a mean value of 91.10 percent. Datta et al. (2002) also reported that residual fraction of B consituted 91.1 to 99.2 per cent of total B, with a mean of 97.1 per cent in some soils of India. In another study, Serrai et al. (1999) reported that, on an average, 78.75 per cent of total B existed as residual form. Residual B was significantly influenced by the soil characteristics under present study. Similar results have also been observed by

Hou *et al.* (1994).

Total boron

Total B content in soils varied from 19.24 to 26.31 mg kg^{-1}, which is well within the reported range (2.8 to 630 mg kg^{-1}) of total B for Indian soils (Takkar and Randhawa, 1978). In all profiles, surface soil contained higher amoung of total B than subsurface soil. Similar results have also been reported in soils of western Gujarat by Hadwani et at. (1989). No significant correlations have been observed between total B and soil characteristics.

Existence of dynamic equilibrium among different fractions of B in soils was confirmed from the correlation data (Table 5), which indicate that any change in soil management practices may affect B equilibrium and B availaibility in soil. The state of dynamic equilbrium was found from the fact that readily soluble B and specifically adsorbed B, specificaly adsorbed B and organically boud B, and residual Band total B have high 'r' values. Residual and total B had the highest correlation value indicating that the residual and toal B were dependent on each other. Dynamic equilibrium among different fraction indicates that the depletion of B concentration in one pol readily available to plants is replinished from other pools of soil B,. Similar observations have also been reported by Tsadilas *et al.* (1994).

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CHANGES IN HOST ENZYME ACTIVITY DUE TO INDUCTION OF RESISTANCE AGAINST DOWNY MILDEW IN CAULIFLOWER

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ABSTRACT

Control of foliar disease downy mildew is a major priority in cauliflower crop system. Seed treatment and foliar application that induce systemic resistance can be an ideal way to provide protection against disease during the establishment of the crop. CGA245704, a chemical activator (abiotic elicitor), Booty (*Trichoderma viride*), a biological elicitor were applied at various doses. Both the seed treatment and foliar application were advantageous. Resistance was recorded up to 24 days after sowing in Bion 50 mg L^{-1} seed treated plants. In Bion 50 mg L^{-1} foliar application resistance was recorded up to 36 days after sowing. Advantage of 12 days for delaying disease symptoms was recorded in pre-inoculated plants. Significant Increase in Phenylalinine ammonia lyase and peroxidase activities in the treated plants very well highlight the significance of use of elicitors in inducing resistance in cauliflower against downy mildew.

Key words : Induced reisistance, downy mildew, culiflower, phenylalanine ammonia lyase, peroxidase, disease infection index.

Downy mildew of cauliflower (Brassica oleracea var. Botrytis sub-var. cauliflora), caused by *Peronospora parasitica* (Pers. ex. Fr.) Fr., economically significant in areas of the world with persistent cool damp weather, when high humidity and air movement favour sporulation, dissemination and infection by the caused fungus. At present, the main disease management options are the application of fungicides and the use of cultivars with resistance based on single genes. The disadvantages associated with both these measures have provided an incentive to develop more economical, environmentally sound and reliable disease control. To this end, much research effort is being channeled towards accentuating natural disease resistance under the control of complex physiological, biochemical and genetic processes, which are not vulnerable to erosion, by change in pathogen virulence.

It is well established that many factors may act on plants to include high levels of systemic resistance to subsequent pathogen attack. These include prior pathogen attack and various chemical and environmental stimuli (Kuc, 1995). Induction so systemic resistance is associated with gene induction, the activation of a wide range of disease resistance mechanisms and the production of a wide range of defence compounds, it is race non-specific and is after effective against a broad spectrum of pathogenic agents (Kuc, 1995).

Certain bio-control agents such as *Trichoderma viride* acts as a biotic elicitor probably due to their capacity to enduce defence reaction in the host (Lughtenburg et al., 1991). *Trichoderma viride* is shown to enduce peroxidase during hypersensitive like reaction of grapevine cells (Calderon et al., 1994).

Present investigations were carried out to study the effect of abiotic and biotic elicitors in inducing disease resistance and resistance related enzymes.

MATERIALS AND METHODS

The experiment was conducted during Novermber 1999 to March 2000 in greenhouse Phytotron Facility, IARI, New Delhi and in the fields of IARI. Cauliflower variety 'Pusa Himiyoti', which is highly susceptible to downy mildew, was used as a host. A highly susceptible variety to downy mildew 'Pusa Himjyoti' of *Brassica oleracea* var *botrytis* was used as a host throughout the experiments. Treated seedling were raised in 6" plastic pots. Seeds were sown about 1 cm deep in a soilless medium containing sand, coconut peat and vermiculite at the ratio 2:1:1. The seedlings were raised under greenhouse conditions. Seven-day-old seedlings were inoculated with a conidial suspension of *Peronospora parasitica* (2×10^4 conidia mL^{-1}) with the help of microsyringe. Plants were inoculated with conidial suspension (2×10^4 condia mL^{-1}) with the help of haemocytometer prepared by harvesting sporangia from incubated cauliflower leaves/infected with the fungus (Bains and Jhooti, 1976). Seed of cauliflower were imbibed for 24 h in a suspension of CGA 245704 made up in sterile distilled water (SDW) followed by during (I+D) seed were then air dried on filter paper at room temperature for 24 h prior to sowing. The following concentrations of activator were tested : 0 (SDW control), 20, 30 and 50 mg $litre^{-1}$. For preinoculation and post inoculation experiment the spray application of activators was given by using above concentration : Booty, a commercial preparation of T. viride [2×10^9 (cfu/g) applied at the rate of 5 gm in 1 litre water and captafol 3g/kg. Normal seed dressing procedure were followed. Development fo Downy mildew of cauliflower was assessed by two parameters : Sporulaion Intensity and Disease infection index.

Assessment of sporulation intensity

Seven days after inoculation, each seedling was assessed for sporulation intensity on cotyledons by using a scale from 0 to 5 (Jensen, 1998) :

0 = no sporulation.

1 = sporulation confined to point of infection and not exceeding 3-4 conidiophores.

2 = sporulation covering inoculation site.

3 = sporulation covering more than inoculation site.

4 = sporulation covering whole cotyledon.

5 = Heavy sporulation on the whole cytyledon.

Assessment of disease severity downy mildew on cauliflower.

All the plants from each treatment scored following 0-4 scale, viz.

0 = no disease.

1 = 1-10% damage of leaf area.

2 = 11=20% damage of leaf area.

3 = 21-49% damage.

4 = 50% or more damage.

Phenylalanine ammonia lyase and total soluble peroxidase assays

Subsamples of planting material were collected at the time of inoculation with conidia of *Peronospora parasitica* and 0, 12, 24, 36, 48 and 60 days after inoculation in preinoculated plants and 0, 12, 24, 36, 48 and 60 days after inoculation in postinoculated plants. SDW-treated plant samples were sampled at the same times for the control. For each treatment, a 2g sample was homogenized in 20 ml of homogenization buffer (0.1 M potassium phosphate, 50m M sodium metabisulphite, 1mM phenyl methyl sulphonyl fluoride, and 250 mM sucrose, pH 7.0). The homogenate was mixed with 2.5 g of polyvinylpolypyroolidone (standard, grade, sigma Chemicals Co., St. Louis) and 1.25 g of Amberlite XAD^{-4} (standard grade, sigma) ion exchange resin for 2 min, filtered through two layers of muslin cloth, and centrifuged at 100,000 × g at 4^{0}C for 30 min. A 2 cm Sepharose G25 mini-column (3,000 rpm for 5 min at 4^{0}C). The G25 column removes excess salt and simple organic acids that might interfere with both the phynylalanine amonia-lyase and total soluble peroxidase assays (Koukal and Conn 1961). For PAL, 50 µl of supernatant was mixed with 950 µl of substrate buffer (10 mM L-phenyl alanine in 100 mM potassium borate, pH 8.8) and the formation of t-cinnamic acid was measured at 290 nm after 2h of incubation at 30^{0}C. PAL activity was expressed as nanomoles of t-cinnamic acid per gram fresh weight per hour. For peroxidase, 50 ml of supernatant was mixed with 950 ml of substrate buffer [4.5 mM guaiacol (50 ul], 2.2 mM hydrogen peroxide, and 200 mM potassium phosphate, pH 5.8) (Reuveni and Perl 1979). the formation of tetraguaiacol was recorded spectronically at 470 nm for 2 min, and a rate was determined. Peroxidase activity was expressed as nanomoles tetraguaiacol per gram fresh weight per hour. Six assays, for both PAL and peroxidase were performed for each sample.

RESULTS AND DISCUSSION

Effect of seed treatment with biotic and abiotic elicitors on the development downy mildew on cauliflower.

Mean sporulation intensity

The sporulation intensity of each treatment is assessed after 7 days of inoculation by the method given by Jensen (1998). There is a significant difference in the sporulation intensity of each treatment than control as given in Table 1. The lowest value of sporulation intensity was observed in Bion 50 mg^{-1} (0.85 followed by Bion 30 mg L^{-1} (1.54), Captafol (2.08) that was 77%, 60% and 45% less than the control treatment. Statistically significant difference was not observed in Bion 20 mg L^{-1} and Booty but the values of sporulation intensity were significantly lower than that of control.

Table 1. Mean sporulation intensity of Perenospora parasitica on cotyledons in seed treated plants (7 days after inoculation)

Treatments	Mean sporulation intensity
Control	3.78
Captafol	2.08
Booty	2.91
Bion 50 (mg l^{-1})	0.85
Bion 30 (mg l^{-1})	1.54
Bion 20 (mg l^{-1})	2.99
C.D. (P=0.05)	0.022

Disease infection index

Downy mildew severity was assessed on 0-4 scale at a regular interval of 12 days. Data presented in Table 2 clearly shows that there is a significant difference in disease severity in each treatment. Among these the best results were shown by Bion 50 mg L^{-1} concentration. The disease severity was below 2 on 0-4 scale up to 60 days. There is no significance difference in case of Bion 30 mg L^{-1} and Captafol. In case of Booty disease severity was higher than Captafol and Bion 50 mg L^{-1}. While comparing three different concentratins of CGA245704 (Bion), the maximum reduction of disease is 59% in case of Bion 50 mg L^{-1} followed by Bion 30 mg L^{-1} and Bion 20 mg L^{-1}. The reduction of disease severity is 36% and 20% less than in control in case of Bion 30 mg L^{-1} and Bion 20 mg L^{-1}.

Effect of foliar pre-inoculation appliction of biotic and abiotic elicitors on the development of downy mildew

As per the data presented in Table 3 there is significant reduction in disease severity in case of Bion 50 ppm, Bion 30 ppm and in case of captafol. There is no significant difference in case of Booty and Bion 20 mg L^{-1} concentration. 50% less disease severity was observed of Bion 50 mg L^{-1} than control at each interval.

Effect of foliar post-inoculation application of biotic and abiotic elicitors on the development of downy mildew

Table 2. Disease severity index of downy mildew due to seed treatment with biotic and abiotic elicitors

Treatments	Day after sowing				
	12	24	36	48	60
Control	2.16	2.60	3.11	3.41	3.58
Captafol	1.257	1.72	1.97	1.17	2.33
Booty	1.56	2.07	2.01	2.43	2.61
Bion 50 (mg l^{-1})	0.91	1.01	1.29	1.40	1.56
Bion 30 (mg l^{-1})	1.16	1.63	2.01	2.22	2.48
Bion 20 (mg l^{-1})	1.83	2.01	2.27	2.58	3.18
C.D. (P=0.05)	0.099	0.12	0.17	0.39	0.17

Table 3. Effect of biotic and abiotic elicitors on disease severity index in pre-inoculated plants

Treatments	Day after sowing				
	12	24	36	48	60
Control	1.09	2.57	3.07	3.23	3.45
Captafol	1.5	1.6	1.8	2.11	2.59
Booty	1.9	2.0	2.5	2.9	3.11
Bion 50 (mg l^{-1})	0.58	0.71	1.09	1.25	1.85
Bion 30 (mg l^{-1})	0.9	1.11	1.77	1.85	2.17
Bion 20 (mg l^{-1})	1.5	1.7	2.34	2.45	2.78
C.D. (P=0.05)	0.31	0.05	0.13	0.27	0.11

Disease severity was observed at 12, 24, 36, 48 and 60 days after sowing clearly indicate that disease severity was low in case of Bion 50 mg and captafol, which was considerably lower as compared preinoculation treatment. Disease severity was higher in each treatment than in pre-inoculated plants. The Table 4 clearly shows that at 60 DAS, the susceptibility was well expressed. No significant differences were observed in Bion 50 mg L^{-1} and Captafol treatments. Disease severity in case of Booty is significantly higher than Bion 50 mg L^{-1} and Captafol.

Effect of pre-inoculation treatments of biotic and abiotic elicitors on phenyl alanine ammonia lyase and peroxidase enzyme activity

PAL activities increased in pre-inoculated control but at a slower rate than in other treatments. There is net and significant increase in PAL activity in plants, treated with Bion at a concentration of 50 mg L^{-1} (Fig. 1), while treatment with Bion 30 showed increase in PAL activity but at a significantly lower than Bion 50 mg L^{-1}. PAL activities Captafol, Booty and Bion 20 mg L^{-1} is higher than control. There has been no significant difference in enzyme activities of captafol, Booty and Bion 20 m mg L^{-1} the presistent increase in PAL activity was up to 19.19% than in control while in Bion 50 mg L^{-1} treated plants the increase was up to 36% at 5th day of inoculation Fig. 1.

Table 4. Disease severity index in post-inoculated plants

Treatments	Day after sowing				
	12	24	36	48	60
Control	2.09	2.57	3.07	3.23	3.45
Captafol	1.50	1.86	2.42	2.68	2.95
Booty	2.05	2.45	2.98	3.16	3.28
50 (mg l^{-1})	1.95	2.01	2.11	2.55	2.98
Bion 30 (mg l^{-1})	1.81	2.04	2.58	2.97	3.07
Bion 20 (mg l^{-1})	1.95	2.15	2.76	3.06	3.22
C.D. (P=0.05)	0.21	0.10	0.37	0.41	0.41

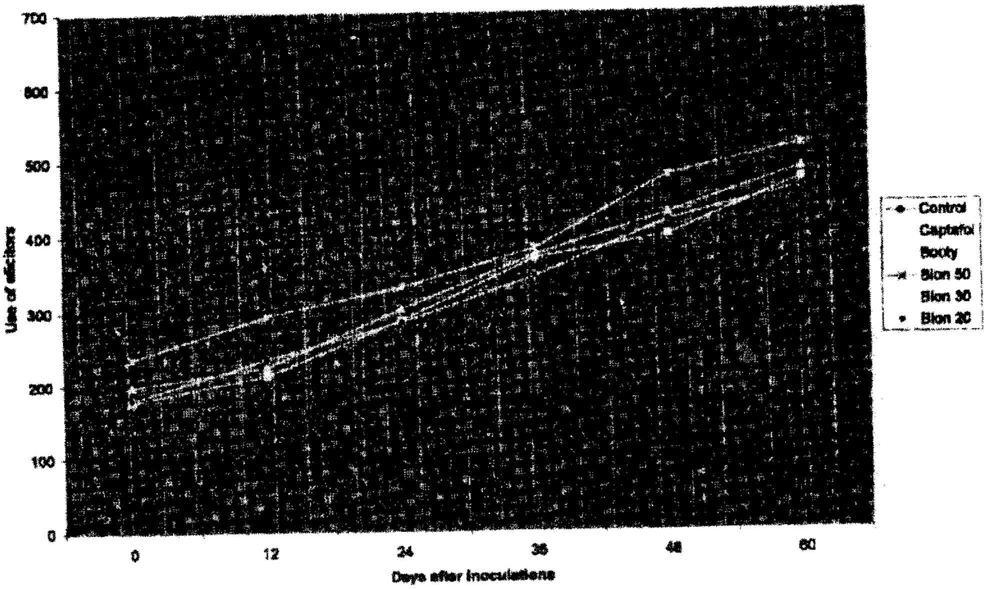

Fig. 1. Phenylalanine ammonia lyase activity in pre-inoculated plants

Levels of peroxidase activity in pre-inoculated elicitors applied plants are shown in Fig. 3. The peroxidase activity was significantly higher. Captfol, Booty, Bion 30 mg L^{-1}, Bion 20 mg L^{-1} and in control. More than 50% increase in peroxidase activity activity was observed in Bion 50 mg L^{-1} plants. There was significant increase in enzyme activity Bion 30 mg L^{-1} also but significantly lower than Bion 50 mg L^{-1}. There is no significant increase in peroxidase activity of Captafol, Booty and Bion 20 mg L^{-1} treated plants, but steady increase in peroxidase activity was observed in all treatments.

Effect of Post-inoculation treatment of Biotic and Abiotic Elicitors on phenylalanine ammonia lyase and peroxidase enzymes activity

PAL activity increase in each treatment of post-inoculated plants but it is relatively very much lower than in pre-inoculated plants. PAL activity as presented in Fig. 2 not shows nay particular trend, but PAL activity in Bion treated plants shows relatively higher activity than in Booty and Captafol treated plants. No significant difference in PAL activity of Booty and Captafol treated plants was observerd.

Peroxidase activity in post-inoculated plants has shown increasing trend (Fig. 4). Significant increase in peroxidase activity in Bion 50 mg L^{-1} in post-inoculated plants was also observed. The values were lower when compared to preinoculated plants. Peroxidase activity increased significantly in Bion 50 mg L^{-1} and Bion 30-mg L^{-1} treated plants but it is considerably lower

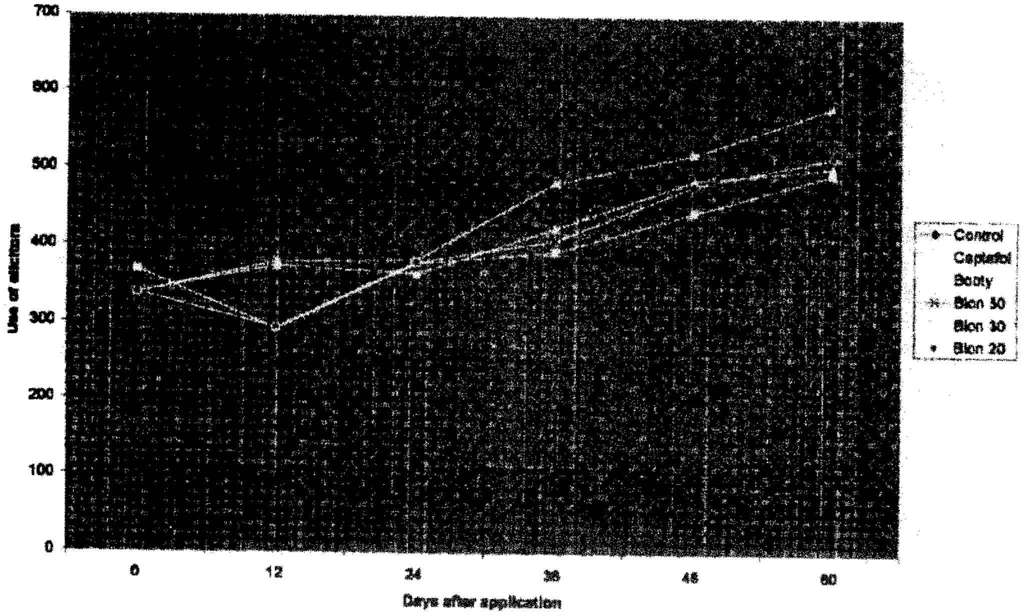

Fig. 2. Phenylalanine ammonia lyasee activity in post inoculated plants

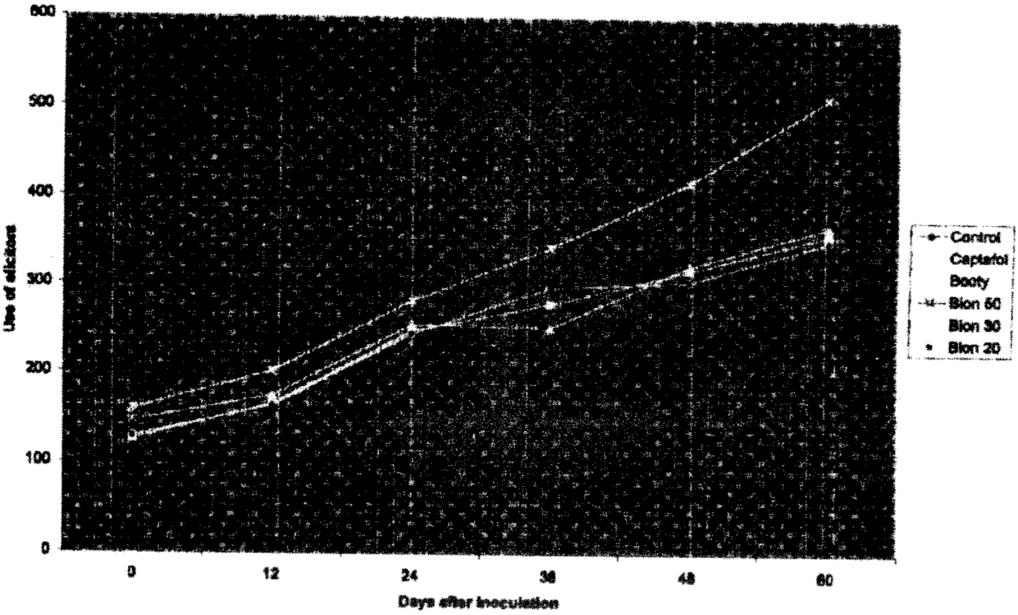

Fig. 3. Peroxidase activity in pre-inoculated plants

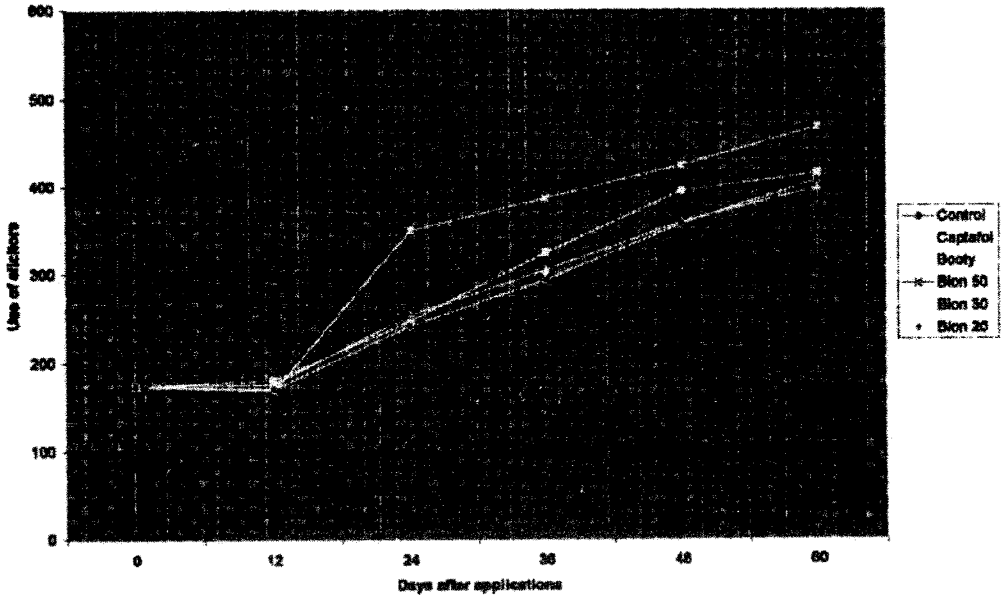

Fig. 4. Peroxidase activity in post inoculated plants

than in pre-inoculated plants. The enzyme activity in each treatment of post-inoculated plants was relatively less than in preinoculated plants.

In the present investigation on seed treatments, two concentrations of Bion, 50 mg L^{-1} and 30 mg L^{-1} were found effective in reducing the sporulation intensity of *Peronospora parasitica* on cotyledons and significant reduction in disease severity, may be due its well know property to induce resistance and inhibiting the mycelial development by triggering the various defence related pathways (Gorlach, 1996) significant reduction in sporulation intensity on cotyledons thn control was observed also in the case of Booty and Captapol but it has been comparatively less than Bion 50 mg L^{-1} and Bion 30 mg L^{-1}. The results may indicate that the reduction in intensity in Booty treated plants may be not due to the induction of resistance but other mechanisms or inhibitory effect of ingredients may be involved (Papavizas and Lumpsden, 1980). It was been observed that the disease severity was highly reduced by Bion 50 mg L^{-1} followed by Bion 30 and Captafol. The least reduction in disease severity was recorded in Booty treated plants.

In experiment, plants were provided with preinoculation treatmens of three different concentrations of Bion viz. 50 mg L^{-1}, 30 mg L^{-1} and 20 mg L^{-1} and recommended concentration of Booty and Captafol. The investigations were carried out on disease severity and the enzymes of defence pathways viz. Phenylalanine amonia lyase and Peroxidase. Disease severity was assessed at regular intervals. Bion 50 mg L^{-1}

and Captafol have shown significant reduction in disease severity. There has not been any significant difference in disease severity of Booty and Bion 20 mg L^{-1} was found. The reports on disease control by *Trichoderma viride* were mainly against soil borne pathogens (Papavizas, 1980) which may not have antagonistic activity against airborne foliar pathogens hence *Trichoderma viride* may not have expressed any significant activity against *Peronospora parasitica.*

Mean sporulation intensity assessed in sad treated plants clearly shows the significant reduction in sporulation intensity on first and second true leaves of cauliflower in Bion 50 mg L^{-1} and Bion 30 mg L^{-1}. This result clearly indicates the systemic induction of resistance from cotyledons to first and second true leaves of cauliflower and has also been reported by Sharma, 2002. Singh et al. (1999) reported systemic induction of resistance in *Brassica juncea*, in first and second true leaves when inoculated with incompatible race of *Albugo candida*. In the present investigation of defence related enzymes viz. PAL and Peroxidase has shown the increasing trends in all the pre-inoculation treatments including control treatment. However, there has been significant increase PAL activity in Bion 50 mg L^{-1} follwed byBion 30 mg L-1 and Booty. PAL activity increased in Bion 50 mg L^{-1} and Bion 30 mg L^{-1}. The other treatments shows moderate increase but not at a significant rate between them. There is a positive correlation between disease resistance and increase in enzyme activities. Similar kinds of results were obtained in case of peroxidase activity in all the pre-inoculation treatment plants.

The increase in PAL activity indicates activation of the phenyl propaniod pathway. In the establishment phase of the pathogen in the host, tissues, PAL activity often increases. In several host pathogen interactions, increased levels have been shown to be correlated with incompativility (Rathmell, 1973; Battacharya and Ward, 1988; Ralton et al., 1989). The product of PAL is trans-cinnamic Singh et al., 1999 that is an immediate precurson for the biosynthesis of salicyclic acid, a signal molecule in SAR (Klessig and Malamy, 1994). Enhanced peroxidase activity vaery often is associated with resistance phenomena such as lignin production (Ride, 1975; Hammerschmidt and Kuc, 1982; Reuveni et al., 1991). Peroxidase activity was positively correlated with levels of resistance/susceptibility of melon plants before infection with *Pseudeperonospora cubensis* and in susceptible plants enhancement of peroxidase occurs too late to prevent development of the disease.

In post inoculation experiment, disease severity was reduced in Captafol and Bion 50 mg L^{-1} treated plants but the extent of control is less as compared to pre-inoculation treatment plants. This may happen because in post inoculated plants pathogen is already established and elicitors, which has not having any fungicidal properties (Gorlach, 1996).

Therefore, the use of activator is recommended before diseases development. PAL activity has not shown any particular trend in all the treatments in post-inoculated plants. Peroxidase activity has also shown increasing trend but comparatively lesser extent than pre inoculated.

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EFFECT OF VARIETIES, SOWING DATES AND NITROGEN LEVELS ON YIELD, NUTRIENT UPTAKE AND QUALITY OF DURUM WHEAT (*TRITICUM DURUM* DESF.)

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Abstract

A field experiment was conducted on loamy sand soil having low nitrogen, medium phosphorus and potassium status at Research farm, Agricultural Research Station, Durgapura, Jaipur during two consecutive *rabi* season in the year 1998-1999 and 1999-2000. The experiment consisted twenty four treatments comprising combination of two varieties (WH 896 and Raj 1555), three sowing dates (1 Novermber, 15 Novermber and 1 December) and four levels of nitrogen (30, 60, 90 and 120 kg/ha). These were evaluated under split plot design with three replications, allocating combinations of varieties and sowing dates in main plots, in sub plots N levels were evaluated. Results revealed that recently released variety WH 896 recorded significantly increased in grain and biological yield and their nitrogen uptake over Raj 1555. These varieties did not differ significantly in straw yield. In contrast to yield potential, Var. WH 896 failed to suppress Raj 1555 in quality parameters recorded in terms of grain appearance score and β-carotene content. At the same time, marginally higher yellow berry prevalence was observed in variety WH 896 compare to Raj 1555. The durums sown up to first fortnight of Nov. (1-15 Nov.) significantly enhanced grain, straw and biological yield/ha and N uptake closely followed by normal sowing over late sowing. The shift in sowing from 1 Nov. to 1 Dec. reduced sedimentation value of flour, while yellow berry appearance was least under normal sowing. Grain appearance, hectoliter weight and β-carotene did not vary between sowing dates. Application of N up to 120 kg/ha significantly produced higher grain, straw and biological yield. Alike crop productivity, N uptake and quality (grain appearance, hectoliter weight, sedimentation value and β-carotene) of durum grains or flour were improved with each increment up to 120 kg N/ha. Whereas, yellow berry prevalence was least under highest level of N.

Key words : Durum wheat, varieties, sowing dates, yield, nitrogen, quality.

The spectacular increase in wheat production from merely 12 million tonnes in mid sixties to 73 million tonnes in the year 1999 has not only elevated over national status from "shortages" to "surplus" in wheat but also opened new avenues for its diversified utilization. In spite of impressive achievements in recent past, concentrated efforts still needed for achiveing sustain growth in wheat production to fulfill nutrition requirements for ever increasing population, maintaining buffer stock for food security and adequate supplies to wheat based food processing industries. It has been projected that to feed 1.3 billion population and diversified uses, India will have to produce at least 109 million tonnes of wheat by 2020 AD, which seems to achieve only through elevating productivity up to 40 q/ha (DWR, 1997). Durum wheat production is still very low (3 million tonnes annually) and grown in very small area (1.5 million ha area). Although it have diversifield uses in industries. Its productivity can be improved through adopting improved varieties, production technologies and proper agronomic practices. Therefore, renewed research and development efforts are needed to exploit potential of major wheat growing areas not only in quantitative terms, but also qualitative. The development and identificaiton of high yielding, widely adopted, disease resistance varieties with good quality characteristics is considered to be first and most step to generated appropriate production technology for a region to increase productivity of durum wheat. Appropriate sowing time play an important role in the production of durum wheat because early as well as too late sown crop generally faces adverse climatic conditions, insect-pest attack etc. The addequate mineral nutrition particularly N fertilization is considered to be most important for exploiting potential of durums due to its involvement in various processes of physiological significances. In view of these facts and paucity of adequate experimental evidences on these aspects, present experiment was taken.

MATERIALS AND METHODS

Field experiment was conducted during winter (*rabi*) seasons of 1998-99 and 1999-2000 at Research farm, Agricultural Research Station, Durgapura, Jaipur. The soil of experimental site was loamy sand with pH 8.0. The available soil, N, P, and K were 150, 40 and 190 kg/ha, respectively. The experiment was laid out in split plot design with three replications. The experiment consisted 24 treatments comprising combinations of two varieties (WH 896 and Raj 1555), three sowing times (1 November, 15 November and 1 December) allocated in main plots and four levels of nitrogen (30, 60, 90 and 120 kg/ha) in sub plots were evaluated. The test durum varieties were sown on stipulated dates as per treatments. A uniform dose of 60 kg P_2O_5/ha, 40 kg K_2O/ha through SSP and muriate of potash, respectively and half nitrogen dose as per treatment through urea were drilled in furrows before sowing. The remaining half dose of N as per treatment was top dressed just before first irrigation applied at CRI stage. The seeds were drilled in rows at 20 cm apart at a soil depth of 5 cm.

RESULTS AND DISCUSSION

Yield : A perusal of data (Table 1) revealed that var. WH 896 produced significantly higher grain and biological yield over Raj 1555 in both the years, whereas, remains at par in straw yield. Since wheat yield formation is a complex process and governed by complimentary interaction between source (photosynthesis and availability of assimilates) and sink component (storage organs). Thus, as a comsequence of marked improvement in both these regulative process as evinced from higher accumulation of biomass and nutrients as well as yield components under variety WH 896 led to significant increase in production of grain in biological yield. Further results showed that both the varieties were at par in straw yield. This seems to be due to variation in harvest index between the varieties. It was observed that variety WH 896 was efficient in utilizing biomass toward yield formation, which might have led to reduced straw weight. The marked variation in yield potential between durum varieties was also observed under multi location trails in North-Western Plain Zone (DWR, 1996). Irrespective of years, early sown crop produced yield but failed to record significant gains over normal sowing. However, both early and normal sown crop produced significantly higher grain, straw and biological yield over late sown crop (Table 1). Thus as a consequence of favourable climatic conditions, improvement in growth and yield components under early and normal sowing resulted in realization of higher yield compare to late sowing. Similar findings were also reported by DWR, 1995. Each increment in N levels from 30-120 kg/ha significantly increased grain, straw and biological yield during both the years (Table 1). The marked improvement in crop productivity is seems to be due to its profound role in exploiting inherent potential for vegetative and reproductive growth of the crop. The results of the present study are in close conformity with Kumar *et al.* 1999.

Nitrogen uptake

Date (Table 1) showed that between varieties, WH 896 accumulated significanlty higher quantum of N in grain compare to Raj 1555 during both the years. Whereas, both the varieties were at par with respect to N uptake by straw. Nutrient uptake is depending on concentration on cellular level and dry matter production. Hence, inspite of marginal variation in N concentration, higher N uptke could be due to increased biological yield. The results are in close conformity with findings of Buldak, 1994. The grain and straw produced under normal sowing did not differ significantly but accumulated significantly higher amount of

Table 1. Effect of varieties, sowing dates and nitrogen levels on yield (q/ha) and nitrogen uptake (kg/ha) of durum wheat

Treatment	Grain yield		Straw yield		Biological yield		N Uptake			
							Grain		Straw	
Variety	1998-99	1999-00	1998-99	1999-00	1998-99	1999-00	1998-99	1999-00	1998-99	1999-00
WH 896	40.38	40.77	51.51	52.69	91.89	93.46	84.60	85.77	25.96	26.81
Raj 1555	38.27	38.73	50.28	51.37	88.49	90.11	80.26	82.01	25.96	26.82
C.D.(P=0.05)	1.70	1.61	NS	NS	3.41	2.82	2.62	2.36	NS	NS
Sowing date										
Early	41.28	42.04	52.68	54.56	93.96	96.61	84.56	84.49	26.62	28.09
Normal	40.59	41.59	52.28	54.33	92.87	96.02	85.38	88.54	26.70	27.88
Late	36.11	35.52	47.71	47.20	83.75	82.72	77.36	76.64	24.55	24.50
C.D.(P=0.05)	2.08	1.97	1.76	1.76	4.18	3.45	3.22	2.89	1.21	1.12
N (kg/ha)										
30	32.40	32.90	44.69	44.13	75.08	77.03	64.83	66.10	20.95	22.04
60	37.79	38.28	48.37	49.48	86.16	87.77	78.30	79.42	24.50	25.28
90	42.36	42.75	54.49	55.56	96.84	98.32	89.43	90.93	28.14	28.78
120	44.75	45.06	58.03	58.98	102.68	104.03	97.17	99.11	30.24	31.18
C.D.(P=0.05)	1.37	1.36	1.78	1.78	2.97	2.90	3.59	3.14	0.94	0.86

N compare to late sowing in each year (Table 1). Irrespective of years, each increment in fertilization significantly increased N uptake by grain and straw. Significantly increase in N uptake by grain and straw yield. The results of present study are in line with those of Kumar *et al.* 1995.

Quality

The quality estimates revealed that grain/flour of variety Raj 1555 was significantly superior in grain apearance score, β-carotene and reduced prevalence of yellow berry in comparison to variety WH 896 (Table 2). However, flour of WH 896 has significantly higher sedimentation value compare to Raj 1555 but other parameters namely hectolitre weight did not vary significantly. The marked improvement in grain appearance score of Raj 1555 over WH 896 could be ascribed to higher 1000 grain weight. The boldness of grains along with luster is important parameters for scoring physical apearance of grain. Further it is well established that both quantity and composition of protein markedly influence virtuousness of grains, sedimentation value, gluten concentration, dough strength and loaf quality (Palikan and Belan, 1987). It was observed that amongst quality parameters, only β-carotene and prevalence of yellow berry were significantly altered by variation in sowing dates (Table 2). The late sown crop recorded highest value of β-carotene and minimized prevalence of yellow berry. Since quality of durum grain is mainly influenced by its protein content and composition. Thus, non significant variation in quality parameters could be attributed to fact that shift in sowing failed to alter N content of grain thereby its protein content. While irregular synthesis of protein under early/late sowing might have increased prevalence of yellow berry infested grains compared to normal sowing. The quality estimates indicated that successive increase in N application up to 120 kg/ha significantly improved grain prevalence score but sedimention value of flour recorded significant increase up to 90 kgN/ha (Table 2).

Table 2. Effect of varieties, sowing dates and nitrogen levels on quality of durum wheat

Treatment	Grain appearance (0-10 point)		Hectolitre weight (kg)		Sedimentary value (cc/g)		β-carotene (ppm)		Yellow berry (%)	
Variety	1998-99	1999-00	1998-99	1999-00	1998-99	1999-00	1998-99	1999-00	1998-99	1999-00
H 896	5.500	5.481	78.217	77.831	6.894	6.894	4.430	4.481	6.447	6.917
Raj 1555	6.757	6.422	78.408	77.933	6.522	6.522	5.150	5.050	4.531	4.892
C.D.(P=0.05)	0.110	0.134	NS	NS	0.174	0.174	0.070	0.070	0.104	0.092
Sowing date										
Early	6.100	5.892	44.721	77.254	6.596	6.596	4.832	4.908	5.738	6.250
Normal	6.105	5.945	78.538	78.392	6.754	6.754	4.788	4.713	4.233	5.162
Late	6.180	6.017	78.678	78.000	6.775	6.775	4.750	4.675	6.488	6.300
C.D.(P=0.05)	NS	NS	NS	NS	NS	NS	0.082	0.086	0.127	0.114
N (kg/ha)										
30	5.791	5.737	77.278	76.800	6.444	6.302	4.507	4.339	6.133	6.350
60	5.983	5.878	78,022	77.506	6.506	6.390	4.628	4.706	5.128	5.800
90	6.144	5.963	78.633	78.250	6.700	6.778	4.797	4.906	6.150	6.283
120	6.594	6.227	79.317	78.972	7.183	6.966	5.228	5.111	4.533	5.183
C.D.(P=0.05)	0.071	0.090	0.959	0.921	0.098	0.254	0.078	0.077	0.037	0.024

Further, the highest level of N fertilization minimized prevalence of yellow berry in durum grains during both the years. Hectolitre weight and β-carotene content was recorded highest in 120 kg N/ha. These findings of present investigation are in close conformity with the finding of Kumar and Kumar, 1997.

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EVALUATION OF SOME CYTOPLASMIC MALE STERILE LINES OF RICE IN KONKAN REGION OF MAHARASHTRA STATE

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Abstract

Sixteen CMS and maintainer lines of rice derived from six different sources were evaluated in two seasons viz., Rabi 1998 and Kharif 1999 and observed for pollen/spikelet sterility and performance of agronomic characters. Ten, five and one CMS lines are categorized as early, midlate and late duration, respectively. All CMS lines flowered late as compared to their respective maintainers in both the seasons. Height of all CMS lines was shorter than their respective maintainer lines in both the seasons. The CMS lines viz., IR 68886A, IR 68897A, IR 68901 A, IR 68885 A, G 46 A, IR 58025 A, IR 69628 A and PMS 2 A had complete pollen and spikelet sterility, dwarf plant type, early, midlate and late duration, better panicle exsertion, outcrossing rate and other desirable agronomic traits. These lines can be utilized for exploiting hybrid vigour in rice.

Key words : Rice, CMS line, pollen sterility, hybrid rice, relative stability.

Among the large number of male sterile lines developed by hybrid rice breeders (Virmani and Shiniyo, 1988, Virmani and Wan, 1988), only a few lines, which are stable for complete pollen sterility over the years, are commercially usable. IRRI has developed 75 CMS lines, but only a few possess traits suitable for developing commercial hybrids (Virmani *et al.*, 1991). In this context, the CMS lines developed at IRRI, Philippines, China and PAU, Ludhiana, India alongwith their corresponding maintainers from six different sources were evaluated to assess their stability for sterility and agronomic performance during Rabi and Kharif season and to isolate suitable CMS line for commercial use in Konkan region of Maharashtra state.

Materials and Methods

The experimental material consisted of sixteen CMS lines derived from six cytosterile source and their respective maintainer lines (Table 1). The seed of sixteen CMS lines (A) and their maintainers (B) were sown in nursery beds during Rabi 1998 and Kharif 1999 seasons. To improve synchronization of flowering, a staggered seeding of the maintainer were carried out at 4 and 8 days intervals after seeding male sterile line. Twenty-five days old seedlings of each CMS lines were transplanted in experimental plot in paired row and single seedling/hill in Rabi and Kharif seasons. Each 'A' line was flanked by a single B line on both side and plants from early and late B line planting are alternated in the row. One additional B line of early sowing was also transplanted on both sides. Both A and B lines were transplanted on the same day. In each row, 20 plants for both A and B lines were maintained at 20 × 20 cm spacing. The row direction was perpendicular to the wind direction. The experiment was conducted in Randomized Block Design with two replications. At the boot leaf stage of 'B' line, 2.0 meter high polythene barriers were erected to cover the three sides of A and B lines in each replication, leaving a gap of 20 cm from the ground. The open side was covered by the barrier of the apposite A and B, to prevent outcrossing by other B lines or to avoid contamination from foreign pollen grains. The CMS lines allow to be naturally pollinated by B lines by tapping the B line with bamboo sticks during anthesis. Appropriate field management and cultural practices were undertaken.

To estimate pollen sterility, spikelets from lower, middle and top portion of the panicle per plant of CMS line were randomly selected. Ten spikelets were collected at the time of flowering and fixed in a vial containing 70% alcohol. Anthers of each spikelet were smeared in 1-% iodine potassium iodide solution and pollen grains were observed under light microscope. Count of completely unstained shrivelled pollen grains indicating sterility was taken and expressed in percentage. At the time of panicle exergence, one panicle in each of the five randomly chosen plant of A and B line was bagged with butter paper bag. Spikelet fertility estimates were taken from a number of fertile and total spikelets from bagged panicles per plants. Data on five randomly selected plants per A and B were recorded from agronomical characteristics viz., productive tillers, plant height (cm), days to 50% flowering, panicle exsertion, spikelets per panicle, outcrossing rate (%), anther colour as well as shape and grain type. Statistical analysis was done using RBD model.

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences among A and B lines for all characteristics studies except spikelet fertility percentage of B line for two seasons and pollen sterility percentage of A line for Rabi 98, indicating that A and B lines differed significantly among themselves for these characteristics ($p<0.05$). Data on percentage of pollen sterility, spikelet fertility in bagged panicles and mean performance of different characters of CMS and maintainer lines over two seasons have been presented in Table 1.

Pollen sterility and spikelet fertility

Of the sixteen CMS lines studied

Table 1. Estimate of pollen sterility and mean performance of agronomic characters in sixteen cytosterile lines (A) and their maintainers (B) during 1998-99 Rabi and 1999-2000 Kharif

CMSA/B lines	Source	Pollen sterility (%)		Spikelet fertility (%)		Plant height (cm)		Productive tillers/plant		Days for 50% flowering		Panicle exsertion (%)		Spikelets/ panicle		Out-crossing rate(%)		Anther colour and shape	Grain type
		Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	R/K	R/K
IR58025A	WA	100.0	99.6	0.0	0.0	77.2	86.2	19.4	16.2	101.0	94.0	85.4	83.6	188.3	198.0	21.6	15.2	White shrivelled	L.S.
IR58025B		--	--	94.3	89.5	86.2	96.6	16.4	14.2	100.0	90.0	100.0	100.0	194.8	215.3	--	--	Yellow plump	L.S.
IR68279A	WA	100.0	97.4	0.0	2.25	72.0	77.6	11.0	9.9	106.5	93.5	75.7	75.8	139.5	147.5	8.6	6.2	White shrivelled	L.S.
IR68279B		-	-	88.5	84.5	84.0	93.0	10.2	9.2	101.0	89.0	100.0	100.0	146.0	155.5	-	-	Yellow plump	L.S.
IR68886A	WA	100.0	99.8	0.0	0.0	65.0	70.8	15.6	13.8	90.0	77.5	80.2	77.4	140.5	142.4	15.8	13.4	White shrivelled	L.S.
IR68886B		-	-	88.5	85.0	74.0	82.0	11.8	11.0	85.5	73.0	100.0	100.0	147.5	149.5	-	-	Yellow plump	L.S.
IR68888A	WA	100.0	96.7	0.0	1.85	66.6	75.2	14.0	12.0	95.0	82.5	82.5	80.4	166.8	172.0	14.0	11.2	White shrivelled	L.S.
IR68888B		-	-	87.5	84.3	76.5	88.0	11.4	10.4	91.5	78.5	100.0	100.0	181.1	198.0	-	-	Yellow plump	L.S.
IR68897A	WA	100.0	99.2	0.0	0.33	65.0	72.8	12.4	10.0	95.0	81.5	79.0	76.6	167.5	155.5	18.6	13.8	White shrivelled	L.S.
IR68897B		-	-	89.2	86.5	79.0	86.4	11.0	9.2	91.5	77.0	100.0	100.0	149.0	167.8	-	-	Yellow plump	L.S.
IR68899A	WA	99.4	99.6	0.68	0.35	67.4	80.2	11.0	8.6	98.5	85.0	78.5	77.5	145.5	170.0	10.0	6.0	White shrivelled	L.S.
IR68899B		-	-	90.2	88.8	75.2	94.2	9.0	8.4	94.0	80.0	100.0	100.0	164.3	179.5	-	-	Yellow plump	L.S.
IR68901A	WA	99.8	100.0	0.0	0.0	65.0	79.6	13.6	11.0	89.5	77.0	80.0	78.6	139.6	154.0	14.2	11.4	White shrivelled	L.S.
IR68901B		-	-	89.0	88.3	81.4	91.0	11.0	10.2	87.0	72.0	100.0	100.0	151.5	169.5	-	-	Yellow plump	L.S.
IR69628A	WA	100.0	100.0	0.0	0.0	75.0	82.0	13.0	9.4	105.5	92.0	79.0	77.6	154.0	168.8	16.6	12.6	White shrivelled	L.S.
IR69628B		-	-	91.8	87.2	84.0	96.4	10.4	8.4	101.0	89.5	100.0	100.0	170.1	178.8	-	-	Yellow plump	L.S.
IR70960A	WA	99.4	99.8	0.3	0.0	62.0	75.2	11.2	8.2	91.0	83.5	79.5	78.8	131.0	144.0	10.2	7.8	White shrivelled	L.S.
IR70960B		-	-	89.0	87.0	73.2	80.0	10.0	8.0	88.5	79.5	100.0	100.0	146.0	158.3	-	-	Yellow plump	L.S.
IR71564A	WA	99.4	100.0	0.5	0.0	70.0	77.2	12.0	10.0	102.5	91.5	76.8	75.6	141.8	152.8	10.4	7.2	White shrivelled	L.S.
IR71564B		-	-	90.0	88.4	77.0	88.6	11.2	9.0	98.5	87.5	100.0	100.0	156.0	173.0	-	-	Yellow plump	L.S.

CMSA/B lines	Source	Pollen sterility (%)		Spikelet fertility (%)		Plant height (cm)		Productive tillers/plant		Days for 50% flowering		Panicle exsertion (%)		Spikelets/ panicle		Out-crossing rate(%)		Anther colour and shape	Grain type
		Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	Rb	Kh	R/K	R/K
PMS 2 A	WA	100.0	99.8	0.0	0.0	75.6	82.6	16.4	13.2	112.0	105.0	82.5	80.6	165.5	175.5	18.0	13.4	White shrivelled	L.S.
PMS 2 B		--	--	91.5	89.0	86.8	93.2	14.0	12.8	106.0	100.0	100.0	100.0	178.8	187.3	--	--	Yellow plump	L.S.
IR68885A	IR 62829B (Mutant)	99.8	99.6	0.0	0.69	68.2	74.8	12.0	10.0	93.0	85.0	77.2	75.8	124.5	135.3	13.2	9.8	White shrivelled	L.S.
IR68885B		-	-	88.0	85.0	79.2	87.4	11.4	9.2	88.0	81.0	100.0	100.0	138.5	148.5	-	-	Yellow plump	L.S.
IR54755A	A.R.C	100.0	100.0	0.0	0.0	65.8	70.5	11.6	7.9	89.0	76.0	69.5	68.4	114.5	125.5	6.2	5.2	White shrivelled	L.S.
IR54755B		-	-	87.0	86.4	64.2	78.0	9.6	7.0	84.0	72.0	100.0	100.0	127.5	112.5	-	-	Yellow plump	L.S.
G 46 A	Gmbi aca (GAM)	100.0	100.0	0.0	0.0	68.2	79.2	16.0	13.0	86.0	85.0	82.2	79.8	151.3	162.5	16.6	11.8	White shrivelled	L.S.
G 46 B		-	-	92.0	88.8	78.5	89.5	13.0	11.0	81.0	80.0	100.0	100.0	164.0	179.0	-	-	Yellow plump	L.S.
D 297 A	Dessi (Di)	100.0	100.0	0.0	0.0	70.2	79.2	12.4	8.6	86.0	84.0	77.4	76.5	111.6	128.5	10.0	8.2	White shrivelled	L.S.
D 297 B		-	-	88.0	86.3	81.5	84.2	10.2	8.0	82.0	81.0	100.0	100.0	127.5	134.8	-	-	Yellow plump	L.S.
IR66701A	O. prennis	100.0	100.0	0.0	0.0	73.0	80.2	14.0	11.0	104.0	96.0	80.0	78.4	115.0	130.3	9.4	6.4	White shrivelled	L.S.
IR66701B		-	-	91.0	88.0	83.8	89.8	12.4	10.2	99.0	90.0	100.0	100.0	132.3	139.1	-	-	Yellow plump	L.S.
	A	0.22	0.57	0.06	0.20	2.08	2.07	1.26	1.25	1.47	1.26	2.08	1.90	10.64	12.42	1.92	1.36		
	B	-	-	2.59	2.62	2.10	2.09	1.06	1.09	1.63	1.98	-	-	10.53	12.94	-	-		
	A	N.S.	1.71	0.18	0.60	6.28	6.24	3.78	3.76	4.43	3.81	6.25	5.73	32.06	37.42	5.80	4.09		
	B	-	-	N.S.	N.S.	6.32	6.30	3.18	3.30	4.92	5.98	-	-	31.72	38.98	-	-		

A = CMS line B = Maintainer of CMS line L.S. = Long Slender L.B. Long BoldS.B. = Short Bold

Bold figure indicates minimum and maximum rang ein the table possessing WA cytoplasm viz., IR 69628 A, ARC cytoplasm viz., IR 54755 A, Gambiaca cytoplasm viz., G 46 A. Dissi cytoplasm viz., D 297 A and O. perennis cytoplasm viz., IR 66707 AA were completely pollen sterile, and had 100 per cent pollen sterility while no seed set was in that panicle in both the seasons and hence found to be highly stable. The CMS lines IR 58025 A, IR 68886 A, IR 68897 A, IR 68899 A, IR 68901 A, IR 70960 A, IR 71564 A and PMS 2 A of WA cytoplasm and IR 68885 A of mutant cytoplasm recorded more than 99 per cent pollen sterility and less than one per cent spikelet sterility in bagged panicles during Rabi 98 and Kharif 99 seasons and those were found to be stable. The CMS lines IR 68279 A and IR 68888 A of WA source showed low pollen sterility and spikelet fertility and hence were found to be unstable. The CMS IR 58025 A (Siddeq et al., 1994, Gautam et al., 1997, Anonymous, 1998, Sarial and Singh, 1999), PMS 2A (Siddiq et al., 1994, Sarial and Singh, 1999), IR 54755 A (Lara et al., 1992), IR 66707 A (Gautam et al., 1997, Jayamani et al., 1999), IR 68897 A (Gautam et al., 1997, Anonymous, 1998, Jayamani et al., 1999), IR 68628 A (Gautam et al., 1997, Anonymous, 1998), IR 68899 A (Gautam et al., 1997) are reported to be completely sterile and stable. Beside this, all CMS lines showed shrivelled and white anthers (Table 2). This trait in CMS lines is desirable, because it facilitates visual discrimination between fertile and sterile plant and anthesis for practical hybrid seed production.

Agronomic traits

The cytoplasmic male sterile lines should posses good agronomic traits viz., erect plant type, strong tillering ability, the difference in flowering time of the main clum and tillers should be short as for as possible, acceptable grain type, good panicle exsertion, high number of spikelet per panicle, good outcrossing rate which help in getting maximum hybrid vigour and also seed production in A × R or A × B combinations besides pollen and spikelet sterility (Vidyachandra, 1995).

Cytoplasmic male sterile lines included in present study displayed wide variation in days for 50 per cent flowering (76 to 105 days in kharif and 86 to 112 days in Rabi season). Ten CMS lines viz., IR 68886 A, IR 68888 A, IR 68897 A, IR 68899 A, IR 68901 A, IR 70960 A, IR 68885 A, IR 54755 A, G 45 A and D 297 A are categorized as early, while five CMS lines viz., IR 58025 A, IR 68297 A, IR 69628 A, IR 71564 A, IR 66707 A and one CMS line PMS 2 A are as of midlate and late duration respectively (Table 2). It is suggested to exploit all these categories in developing rice hybrids with desired maturity groups. All CMS lines flowered late as compared to their respective maintainers in both the seasons. The maximum difference of 6 days was observed between IR 66707 A and B during Kharif season and PMS 2 A during Rabi season. The results of delay heading in CMS lines than their maintainers have also been confirmed on the studies of earlier workers viz., Pandya et al. (1996), Anonymous (1998), and Jayamani et al. (1999). Delya heading phenomenon is caused possibly because of influence of the sterile cytoplasm.

The highest of CMS lines ranged from 70.5 cm (IR54755 A) to 86.2 cm (IR 58025 A) in Kharif and 62.0 cm (IR 70960 A) to 77.2 cm (IR 58025 A) in Rabi seasons. The height of maintainer lines ranged from 78.0 cm (IR 54755 B) to 96.6 cm (IR 58025 B) in Kharif and 73.2 (IR 70960 B) to 86.8 cm (PMS 2 A) in Rabi seasons. All CMS lines under study were dwarf in nature. In general, height of all A lines was shorter than their respective B lines in both seasons (Table 2). This mechanism facilitates the outcrossing in CMS seed production programme. These results have also been confirmed on the studies of Pandey et al. (1996), Gautam et al. (1997), Anonymous (1998) and Jayamani et al. (1999).

Productivity tillers per plant in CMS lines ranged from 16.2 (IR 58025 A) to 7.9 (IR 54755 A) in Kharif and 11.0 (IR 68297 A and IR 68899 A) to 19.4 (IR 58025 A) in Rabi seasons, while productive tillers per plant in maintainer lines ranged from 8.0 (D 297 B, IR 70960 B) to 14.2 (IR 58025 B) in Kharif and 9.0 (IR 68899B) to 16.4 (IR 58025 B) in Rabi seasons. In general number of productive tillers were observed more in Rabi season than that of Kharif season (Table 2). These results have been confirmed on the findings by Jayamani et al. (1999). The CMS lines had more number of productive tillers than their respective maintainer lines. These results have also been confirmed on the studies of Suprihatno et al. (1994), Pandey et al. (1996) and Anonymous (1998). More number of spikelets is considered to favour more seed set. The wide range of variation was observed among CMS lines with respect to the number of spikelets per panicle under present investigation. The spikelets per panicle in CMS lines ranged from 125.5 (IR 54755 A) to 198 (IR 58025 A) in Kharif and 111.6 (D297 A) to 188.3 (IR 58025 A) in Rabi seasons. While spikelets per panicle in maintainer lines ranged from 112.5 (IR 54755 B) to 215.3 (IR 58025 B) in Kharif and 127.5 (IR 54755 B, D 297 B) to 194.8 (IR 58025 B) in Rabi seasons.

In the straight cultivars, tiller number per plant and spikelet number per panicle although contribute the yield substantially, however, in CMS lines, beside above yield contributing characters, the panicle exsertion and outcrossing rate is of vital important. It has been observed that in CMS lines the panicle exsertion in incomplete. So low seed set in CMS lines having low panicle exsertion is directly due to lower number spikelets exposed to the available pollen. A good panicle exsertion in the male sterile parent would expose a higher number of spikelet for out crossing as compared to male sterile lines showing incomplete panicle exsertion. Similarly incomplete panicle exsertion in a pollen parent would also result in lower pollen release into the air. Therefore, a desired panicle exsertion in both female and male parent in a hybrid seed production plot is essential to attain high outcrossing rate.

In present study CMS line belonging to different CMS source showed significant difference ($p < 0.05$) among themselves for panicle exsertion and outcrossing rate. Panicle exsertion in CMS lines ranged from 68.4% (IR 54755 A) to 85.4% (IR 58025 A) in Rabi season. Maintainer lines exhibited 100% panicle exsertion in both seasons. The seed set as natural outcrossing ranged from 5.2% (IR 54755A) to 15.2% (IR 58025A) Kharif and 6.2% (IR (54755A) to 21.6% (IR 58025A) in Rabi seasons. In general panicle exsertion and outcrossing rate in all CMS lines was higher in Rabi season than Kharif season (Jayamani et al., 1999). This shows that Rabi season favors the seed production in CMS lines. The CMS lines IR 58025A, IR 68886A, IR 68888A, IR 68897A, IR 68901 a, IR 69628A, PMS 2A, IR 68885A and G 46A had higher panicle exsertion (>75 and >77%) and outcrossing rate (>11 and >13%) during Kharif and Rabi seasons, respectively. According to grain type, all CMS lines were long slender except G 46A and IR 70960 A which were short bold and long bold respectively.

The CMS lines viz., IR 68886A. IR 68897A, IR 68901 A, IR 68885A. G 46 A, IR 58025 A, IR 69628A, PMS 2 A had complete pollen and spikelet sterility, dwarf plant type, early midlate and late duration, better panicle exsertion, outcrossing rate as will as other desirable agronomic traits. These lines can be utilized for exploiting hybrid vigour in rice.

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GENETIC DIVERSITY STUDIES IN MUSKMELON

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ABSTRACT

Seventy germplasm lines of muskmelon were evaluated to elucidate genetic divergence using a non-hierarchical Euclidean cluster analysis for yield and its components. The genotypes were grouped into 11 clusters irrespective of geographic and genetic diversity. Group VIII contained the largest number of eleven genotypes. The maximum genetic distance occurred between cluster II and X. On the basis of desirable mean values, 12 superior germplasm lines could be identified which were distributed in 4 different clusters. Majority of the superior lines were confined to cluster III. The 12 superior genotypes were MM-96-83, MM-96-92, MM-97-13, MM-97-28, MM-97-35, MM-97-41, MM-96-43, MM-97-48, MM-97-51, MM-97-52, MM-97-54 and MM-97-100.

Key words : Genetic diversity, musmelon.

Genetic diversity is the basis requirement of a successful breeding programme. Genetic diversities usually thought of as the amount of genetic variability among individuals of a variety, population of species (Brown, 1983). The evaluation data obtained on any germplasm collection represents many duplicate accessions. Such duplicate accessions which differ from each other in one or two characters significantly pose a difficult situation for resolving distinct types. The divergence study in the form of classifications into different homogenous groups is an important practice for estimation of variation within the germplasm. Muskmelon is an important cucurbit and India being the secondary centre of origin, a wide range of genetic diversity is available in this crop. Hence, this investigation was carried out to study genetic divergence among 70 germplasm lines of muskmelon collected from the riverbeds and local markets of the western U.P.

MATERIALS AND METHODS

The experiment comprising 70 germplasm lines of muskmelon was laid out in a randomized block design with two replications during summer 1998. Each plot consisted of single row of 6m length. The spacing between the rows was 2.5m while within the row it was 0.4m. Observations were recorded on five random plants per genotype in each replication for 15 characters viz., days to male flower anthesis, days to female flower anthesis, node number to first fruit set, vine length (cm), number of primary branches per vine, yield per plant (g), average fruit weight (g), fruit polar diameter (cm), fruit equatorial diameter (cm), blossom end scar size (cm), flesh weight per fruit (g) and total soluble solids (%). The genetic divergence was carried out using Non-Hierachical Euclidean cluster analysis as described by Beale(1969) and further elaborated by Spark (1973).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the genotypes for all the attributes under study. On the basis of Non-Hierarchical Euclidean cluster analysis, 70 genotypes were grouped into 11 clusters (Table 1) which indicated a large genetic diversity. The cluster VIII had the highest eleven genotypes. Each of the three clusters III, IV and VII had ten genotypes. The remaining 29 genotypes were distributed in seven clusters, of which 7 were in cluster V, 6 in cluster II, 5 in cluster I, 5 in cluster : VI, 3 in cluster X and cluster XI was a single genotype cluster. Further, it was observed that genotypes belonging to the same location did not always appear in the same cluster but many of them were also distributed in different clusters. It demonstrated that the different locations of adaptability of certain genotypes failed to create enough diversity to allow distribution of genotypes into different clusters. This is more likely to happen in situation like here where the lines were collected from nearby locations within a region (Western Uttar Pradesh) and also because of the fact that the selection by the farmers may have been primarily for only a few desirable fruit traits. Such results have also been reported by Kalloo et al. (182).

Table 1. Grouping of 70 genotypes of muskmelon in different clusters

Cluster No.	Number of genotypes	Genotypes included in the same cluster
I	5	MM-97-5, MM-97-8, MM-97-4, MM-97-2, MM-97-51
II	6	MM-96-88, MM-96-85, MM-96-90, MM-96-42, MM-96-17, MM-96-86
III	10	MM-97-19, MM-97-52, MM-97-48, MM-97-13, MM-97-54, MM-97-39, MM-97-46, MM-97-100, MM-97-41.MM-97-28
IV	10	MM-97-9, MM-97-25, MM-97-33, MM-97-20, MM-97-74, MM-97-79, MM-97-97, MM-97-18, MM-97-35, MM-97-44
V	7	MM-96-94, MM-96-72, MM-96-11, MM-96-75, MM-96-30, MM-96-46, MM-96-45
VI	5	MM-97-40, MM-97-83, MM-97-10, MM-97-92, MM-97-43
VII	10	MM-96-91, MM-96-77, MM-96-16, MM-96-3, MM-96-7, MM-96-93, MM-96-71, MM-96-69, MM-96-31, MM-96-21
VIII	11	MM-97-1, MM-97-89, MM-97-41, MM-97-76, MM-97-26, MM-97-32, MM-97-55, MM-97-22, MM-97-82, MM-97-34, MM-97-78
IX	3	MM-97-37, MM-97-47, MM-97-27.
X	2	MM-96-80, MM-96-53
XI	1	MM-96-99

The grouping pattern of genotypes revealed that none of the oblong fruited genotypes were grouped together with the round fruited genotypes. All the four lines having oblong fruits were distributed into 2 different clusters IX and XI. The genotypes MM-97-27, MM-97-47 belonged to cluster IX while MM-96-99 was along in cluster XI.

The intra and inter cluster distance represent the index of genetic diversity among clusters as given in Table 2. Average distance of cluster members from cluster centroids was found to be maximum (3.21) for cluster X and minimum (0.00) for cluster XI having single genotype. The maximum inter cluster distance existed between cluster centroids of II and X (10.94) followed by cluster IX and X (9.98); I and X (9.91); IV and X(9.36). The distance was minimum between luster V and VII (2.65). The other clusters found to be comparatively nearer to each other were I and VII (2.77), I and III (2.91), I and II (2.92), V and VIII (3.04) etc.

Table 2. Average intra and inter cluster distance values

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	2.07	2.92	2.91	3.86	3.25	3.61	2.77	5.53	4.41	9.91	8.08
II		2.45	3.83	3.61	4.57	4.33	3.11	6.23	3.99	10.94	8.36
III			2.43	3.20	3.27	3.44	3.28	4.44	4.52	8.51	7.30
IV				2.24	3.97	3.05	3.53	4.38	4.13	9.36	7.24
V					2.57	3.20	2.65	3.04	4.58	7.21	5.70
VI						2.26	3.16	3.79	4.68	8.23	7.27
VII							2.45	4.70	3.70	8.89	6.77
VIII								2.78	5.51	5.57	5.42
IX									2.06	9.98	6.06
X										3.21	8.25
XI											0.00

(Underlined values showing intra cluster distance).

Substantial variation was found among the cluster mean values for different characters (Table 3). The yield per plant ranged from a minimum of 883.50 g for cluster II to a maximum of 3557.00 g for cluster X. The minimum average fruit weight was in cluster II (527.08 g) and the maximum in cluster X (2303.08 g). Genotypes with the highest TSS content were found in cluster III (9.60) while the genotype having the lowest TSS content was in cluster XI (4.16). On the basis of yield and fruit quality attributes, 12 superior genotypes (Table 4) MM-96-83, MM-96-92, MM-97-13, MM-97-28, MM-97-35, MM-97-41, MM-97-43, MM-97-48, MM-97-51, MM-97-52, MM-97-54, and MM-97-100 were identified. Seven genotypes were accommodated in cluster III while three genotypes occupied cluster VI. It will be appropriate to mention that these two clusters had higher mean values for TSS i.e., 9.60 and 9.13, respectively. Of the remaining two genotypes, one each occupied cluster I and cluster IV. The fact that 7 out of 12 superior genotypes were included in one cluster i.e. cluster III, indicated less diversity among them. This could be on

Table 3. Cluster mean values for different characters in muskmelon

Cluster	Days to male flower anthesis	Days to female flower anthesis	Node number to first fruit set	Vine length (cm)	No. of primary branches /vine	Yield per plant(g)	Average fruit weight (g)	Fruit polar diameter (cm)	Fruit equatorial diameter (cm)	Seed cavity diameter	Flesh thickness (cm)	Stem end scar size (cm)	Blossom end scar size(cm)	Flesh weight per fruit (g)	TSS (%)
I	47.40	56.50	5.83	239.80	3.70	1085.50	641.92	9.31	11.86	7.70	2.04	1.38	2.55	487.25	7.32
II	50.00	58.75	5.33	297.47	4.55	883.50	527.08	9.06	10.35	6.82	1.85	1.13	1.56	285.00	6.00
III	48.05	57.80	5.10	298.18	3.03	1870.70	826.47	10.41	12.79	8.20	2.38	1.36	1.68	68*.75	9.60
IV	52.75	62.35	6.77	301.72	3.00	1012.75	832.50	10.05	12.47	7.82	2.38	1.45	1.37	643.75	7.13
V	47.79	57.14	6.19	291.95	3.95	1701.86	1039.94	10.94	14.52	9.93	2.28	1.85	2.53	851.85	6.41
VI	49.50	59.90	8.23	281.73	4.37	1423.00	947.50	10.73	12.99	8.05	2.53	1.61	1.92	800.00	9.13
VII	47.10	56.60	7.10	332.92	3.92	1257.90	767.75	10.49	12.24	8.09	2.03	1.45	2.26	623.35	5.93
VIII	51.55	60.23	6.61	305.38	3.89	2764.50	1469.32	13.35	15.53	9.94	2.71	1.80	2.15	1210.11	7.02
IX	49.67	57.67	6.44	291.22	3.56	1391.67	808.33	16.32	10.37	6.97	1.71	1.63	0.95	641.67	4.89
X	48.00	54.75	7.09	355.25	3.91	3557.00	2302.08	14.70	19.97	13.43	3.32	1.66	2.17	2064.58	8.80
XI	49.00	59.50	5.84	370.33	3.50	2815.00	1150.00	18.30	14.95	10.95	1.90	3.20	1.40	875.00	4.16

Table 4. Characterization of superior germplasm lines of muskmelon

S.No.	Genotypes	Days to female flower anthesis	Node number to first fruit set	Vine length (cm)	Number of primary branches/ vine	Yield per plant (g)	Average fruit weight (g)	Flesh thickness (cm)	Total soluble solids (%)	Rind colour	Neeting	Flesh colour
1.	MM-96-83	64.50	8.17	243.67	5.33	748.50	725.00	2.30	10.50	Brownish-orange	Present	Light green
2.	MM-96-92	60.50	7.00	305.67	3.50	1900.00	937.50	2.43	9.84	Yellowish-orange	Present	Light orange
3.	MM-97-13	59.50	5.50	232.67	2.16	2306.00	862.50	2.20	11.67	Yellowish-brown	Present	Light green
4.	MM-97-28	54.00	5.33	287.80	3.00	2740.00	575.00	2.35	10.00	Yellowish-orange	Present	Light Yellow
5.	MM-97-35	60.50	7.83	328.17	3.17	850.00	662.50	1.90	9.17	Mottled-brown	Present	Light green
6.	MM-97-41	55.50	4.50	257.83	3.33	2555.00	750.00	2.80	10.50	Greenish-yellow	Present	Light orange
7.	MM-97-43	58.50	7.83	280.50	5.00	1450.00	1050.00	2.30	9.50	Greenish-orange	Absent	Light orange
8.	MM-97-48	58.00	6.33	350.00	3.00	1365.00	800.00	2.50	9.17	Reddish-brown	Present	Orange-green
9.	MM-97-51	97.50	6.17	231.17	3.16	1385.00	512.50	1.55	9.84	Greenish-orange	Absent	Light orange
10.	MM-97-52	60.50	5.83	265.50	3.33	1140.00	875.00	2.55	9.84	Dark-orange	Absent	Light green
11.	MM-97-54	58.50	5.17	355.33	3.50	2794.00	1181.25	2.62	10.00	Creamy-orange	Present	Light orange
12.	MM-97-100	58.50	5.50	310.70	3.33	2208.00	800.00	2.45	11.33	Yellowish-brown	Present	Light green

account of selection for similar traits by local growers who are largely guided by consumers preference. In muskmelon, consumers' preference is primarily for medium size and round fruits with high TSS content across a wide range of geographical region. It is also suggested that crossing of the genotypes having desirable mean values for yield and quality attributes and high inter cluster distance may lead to greater heterotic expression and broad spectrum of favorable genetic variability in segregating generations for improvement of muskmelon. Thus the crosses of MM-97-13/MM-97-28/MM-97-43 may be worth exploiting through further breeding programme.

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GROWTH AND YIELD OF MAIZE (*ZEA MAYS* L.) AS INFLUENCED BY CROPPING SYSTEM AND MOISTURE CONSERVATION PRACTICES UNDER RAINFED CONDITIONS

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ABSTRACT

A field experiment was conducted during *kharif* 2001 to find out the response of maize to 3 cropping systems and 6 moisture conservation practices under rainfed conditions. Growth parameters viz., dry matter accumulation and LAI, yield attributes viz., cobs/plant, cob length, grains/cob, grain weight/cob and weight of cobs, yields-grain, stover and biological and maize equivalent were significantly improved in maize paired row (40/80 cm) + one row of mungbean over sole maize but on par with maize paired row + two rows of mungbean. Growth, yield attributes and yield as well as maize equivalent were significantly improved with the FYM + dust mulch + straw mulch treatment over no mulch.

Key words : Cropping system, moisture conservation, rainfed, mulches, growth attributes, yield.

Maize, with a production of 12.1 million tonnes from 6.8 mha, ranked third in the world after wheat and rice, but its average national production is only 1.8 tonnes/ha against the world average of about 4.2 tonnes/ha. Weather aberrations have become a common feature for dryland agriculture in India and consequently limiting the maize production. Under such a difficult and demanding situation, spatial or temporal intensification of cropping along with the moisture conservation practices constitutes the linchpin of success of crop production in rainfed areas. Accordingly, an experiment was planned to evaluate the performance of maize as influenced by different intercropping systems and moisture conservation practices.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2001 at the Indian Agricultural Research Institute, New Delhi having 3 cropping systems viz., maize sole (60 cm), maize paired row (40/80 cm) + one row of mungbean and maize paired row (40/80 cm) + two rows of mungbean in main plots and 6 moisture conservation practices viz., no mulch, dust mulch + straw mulch, kaolin + straw mulch, kaloin + dust mulch + straw mulch, FYM @ 5 t/ha and FYM + dust mulch + straw mulch in sub-plots, in split plot design with three replications. The maize cv. Pusa composite

3 was sown on June 21st at an inter row spacing of 60 cm in maize sole and paired row sowing was done at a distance of 40 cm apart keeping 80 cm distance between two pairs of rows. The different mulches were applied as per the treatments.

RESULTS AND DISCUSSION

Growth and yield attributes

In intercropping systems, maize paired row + one row of mungbean recorded significantly higher dry matter, LAI and yield attributes viz., cobs/plant, cob length, grains/cob, grain weight/cob and weight of cobs/plant as compared to sole maize but were at par with maize paired row + two rows of mungbean (Table 1). These results are in close conformity with those of Abbas *et al.* (1995) and Sarkar *et al.* (1998).

Dry matter accumulation, LAI and yield attributes viz., cobs/plant, cob length, grains/cob, grain weight/cob and weight of cobs/plot exhibited a measurable improvement due to moisture conservation practices applied during crop growth period. FYM + dust mulch + straw mulch caused maximum increase in dry matter, LAI and yield attributes (Table 1), followed by kaolin + dust mulch + straw mulch, however, cob girth and 1,000 grain weight were not affected significantly due to mulching practices. The adequate availability of moisture to plant due to reduction in ET have resulted in cell turgidity and eventually higher meristematic activity leading to more foliage development, greater photosynthetic rate and consequently better plant growth, manifested in terms of increased DM, LAI and yield attributes. These findings are on the line of Kaushik and Gautam (1994) and Kaushik and Lal (1997).

Grain and stover yield

Significantly higher grain, stover and biological yields of maize to the tune of 13.7, 7.1 and 9.4 percent, respectively, were recorded in maize paired row (40/80 cm) + one row of mungbean over sole maize (Table 2). However, the yields in intercropping of maize paired row (40/80 cm) + one row of mungbean and maize paired row (40/80 cm) + two rows of mungbean was statistically at par with each other. The improvement in yield could be assigned to the synergistic effect of maize and mungbean association and a better source-sink relationship. Similar results were obtained by Sarkar *et al.* (1998).

The remarkable improvement in grain, stover and biological yields as well as harvest index was recorded in FYM + dust mulch + straw mulch treatment followed by kaolin + dust mulch + straw mulch. The different mulches have resulted in decreased ET losses either by interception of insolation or increasing the leaf albedo or improving the physico-chemical properties of the soil, as the case may be. The results are in close conformity with those of Kaushik and Gautam (1994) and Singh *et al.* (1997).

Maize equivalent

The maize yield equivalent of maize paired row + two rows of mungbean intercroping system was 4.7 and 43.9 per cent higher over the maize equivalent yield recorded under ~~maize paired~~ equivalent yield recorded under maize paired row + one row of mungbean and sole maize, respectively (Table 2). This increase was mainly due to

Table 1. Effect of cropping system and moisture conservation practices on growth and yield attributes of maize

Treatment	Dry matter/ plant (g)	LAI	Cobs/ plant	Cob length (cm)	Cob girth (cm)	Grains/ cob	Grain weight/ cob	Weight of cobs/ plot	1,000-grain weight (g)
Cropping system									
Maize sole (60 cm)	120.85	2.42	1.18	15.00	12.21	325.00	70.25	7.38	248.16
Maize paired row (40/80 cm) + one row of mungbean	130.13	2.88	1.34	17.28	12.65	366.33	90.95	9.28	251.66
Maize paired row (40/80 cm) + two rows of mungbean	131.71	3.01	1.40	17.46	12.70	370.50	94.38	9.72	258.83
C.D. (P=0.05)	6.67	0.15	0.06	0.87	NS	18.13	4.13	0.47	NS
Moisture conservation practices									
No mulch (control)	114.00	2.24	1.13	15.32	12.27	327.00	73.43	7.44	246.33
Dust mulch + straw mulch	129.03	2.85	1.34	16.61	12.55	360.00	86.90	9.05	254.33
Kaolin + straw mulch	127.56	2.77	1.31	16.47	12.51	356.00	85.66	8.82	252.33
Kaolin + dust mulch + straw mulch	129.63	2.90	1.34	16.75	12.59	362.00	87.86	9.12	256.66
FYM @ 5t/ha	126.26	2.76	1.29	16.22	12.42	352.33	84.66	8.63	249.00
FYM + dust mulch + straw mulch	138.90	3.10	1.43	18.13	12.76	386.33	92.93	9.70	258.66
C.D. (P=0.05)	7.63	0.16	0.06	0.99	NS	21.05	4.14	0.50	NS

NS=Non-significant

Table 2. Effect of cropping system and moisture conservation practices on yield (q/ha) and harvest index (%) of maize

Treatment	Grain yield	Stover yield	Biological yield	Harvest index	Maize equivalent
Cropping system					
Maize sole (60 cm)	32.33	60.74	93.08	34.73	32.33
Maize paired row (40/80 cm) + one row of mungbean	36.79(2.81)	65.06	101.86	36.04	44.49
Maize paired row (40/80 cm) + two rows of mungbean	37.31(3.38)	66.49	103.80	35.92	46.53
C.D. (P=0.05)	1.88	2.97	5.69	NS	1.93
Moisture conservation practices					
No mulch (control)	32.59(2.35)	59.86	92.45	35.22	36.85
Dust mulch + straw mulch	35.32(3.15)	64.13	99.45	35.36	41.03
Kaolin + straw mulch	34.75(3.00)	63.94	98.69	35.46	40.19
Kaolin + dust mulch + straw mulch	36.48(3.46)	65.22	101.70	35.83	42.19
FYM @ 5t/ha	34.40(2.97)	63.21	97.61	34.96	39.79
FYM + dust mulch + straw mulch	39.34(3.65)	68.21	107.56	36.53	45.96
C.D. (P=0.05)	2.13	3.53	6.60	1.53	2.03

additional yield advantage of *intercropping* as well as higher market price of grain legumes than that of maize grain.

FYM + dust mulch + straw mulch gave the highest maize equivalent yield due to reduction in evaporation losses which in turn led to extended moisture availability to the crop. These results are in conformity with the findings of Kaushik and Gautam (1994) and Kaushik and Lal (1997).

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SEED YIELD, QUALITY AND ECONOMICS OF SOYBEAN (*GLYCINE MAX* (L) MERRILL) AS INFLUENCED BY LEVELS AND SOURCES OF SULPHUR

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ABSTRACT

A field experiment was conducted to study the effect of source and level of sulphur on medium clay soil. Increasing levels of sulphur from 0-50 kg/ha and sources of sulphur significantly influenced the seed yield quality and economics of soybean. Highest seed yield, protein, oil content and net returns were recorded due to application of 50 kg S/ha. Amongst different sources gypsum proved most effective followed by agricultural pyrites and elemental sulphur, respectively. Highest soybean seed yield, oil, protein content and net return 2257 kg/ha. 20.51% 41.29% and Rs. 16918 was recorded. respectively, due to 50 kg S/ha through gypsum. The highest net return Rs. 16918 which was 57.25% higher over control was recorded at 50 kg S/ha through gypsum.

Key words : Levels and sources of S, soybean yield, oil, protein content and net return.

Although Madhya Pradesh is considered as a major soybean producing state and accounts for major share of the Indias produce, an account of large hectarge. The productivity in India is very low (920 kg/ha) as compared to the world average of 2202 kg/ha (FAO, Rome 1995). There is tremendous scope for productivity enhancement per unit of land, since no sufficient information on soybean responses to sulphur application on medium black soil is available an experiment was conducted to evaluate the impact of different levels and sources of sulphur on productivity and quality of soybean.

MATERIALS AND METHODS

A field experiment was conducted during the rainy (kharif) season of 1996 and 1997 at College of Agriculture, Indore. The soil was medium clay in texture having mean pH 7.5. The available N, P, K and S contents were 220, 13, 618 and 11.75 kh/ha, respectively. The experiment was laid out in four randomized blocks receiving five levels of sulphur (10, 20, 30, 40 and 50 kg/ha) and three sources (Gypsum, Pyrite and Elementl sulphur) along with an absolute control. Sulphur was applied at the time of sowing as per the treatments. Fertilizer N and P_2O_5 at the rate of 20 and 60 kh/ha respectively were applied through di-ammonium phosphate and K_2O at rate of 20 kg/ha through muriate of potash Soyabean (cv. JS 335) was sown in rows 30 cm apart using the seed rate of 100 kg/ha in last week of June every year.

RESULTS AND DISCUSSION

Effect on seed yield

The date presented in table 1 indicate that application of sulphur at the rate of 50 kg/ha through gypsum significantly increased the seed yield of soybean by 38.72% (630 kg/ha) over control. Out of three sources of sulphur gypsum was found superior over pyrite and elemental sulphur, respectively. This might be due to readily available SO_4-S in gypsum than other sources. Similar results have been reported by Ramamoorthy *et al.* (1996), and Dwivedi and Bapat (1998).

Effect on quality

Increasing levels of sulphur significantly improved the quality of soybean in terms of protein and oil content. The increase in protein and oil contents due to application of 50 kg S/ha over control were 11.23% and 3.16%, respectively. Increase in oil content and oil yield due to sulphur application is attributed to the key role played by sulphur in biosynthesis of oil in oilseed plants. The increase in protein content and protein yield may be due to the increase in sulphur containing the amino acids like methionine, cystene and cystine as they are building blocks of protein. Beneficial effect of sulphur fertilization were also reported by Nagar *et al.* (1993). Application of gypsum produced significantly higher content and yield of protein and oil over pyrite and elemental sulphur. This may be attributed to higher availability of sulphur from gypsum. Superiority of gypsum has also been reported by Kandpal and Chandel (1993) in soybean.

Effect on economics

Maximum additional net return of Rs. 16918/ha accrued by the use of sulphur @ 50 kg/ha. Out of three sulphur sources gypsum was found superior and gave highest net return of Rs. 15163/ha followed by pyrite and elemental sulphur. These results confirm the findings of Ramamoorthy *et al.* (1996).

It is evident that the application of sulphur in the form of gypsum followed by pyrite and elemental sulphur @50 kg/ha gave highest seed yield quality and net return over lower levels and control. These results confirm the finding of Tandon (1984).

Table 1. Seed yield, quality and economics of soybean as influenced by source and level of sulphur (Two years pooled data)

Treatments	Seed yield (Kg/ha)	Straw yield (Kg/ha)	Protein Content (%)	Protein yield (Kg/ha)	Oil Content (%)	Oil yield (Kg/ha)	Economics Net Income Rs./ha	C:B Ratio
Sulphur Levels								
Control 0	1627	1811	37.12	604.2	19.88	323.3	10713	1:2.65
10	1739	1961	40.67	707.7	20.02	348.2	11824	1:2.92
20	1874	2123	40.89	766.1	20.19	378.3	13156	1:2.97
30	2028	2320	41.02	831.8	20.25	410.0	14435	1:3.12
40	2161	2509	41.19	890.1	20.41	441.1	16001	1:3.33
50	2257	2665	41.29	931.3	20.51	462.9	16918	1:3.42
C.D. at 5%	49.20	42.48	0.150	10.04	0.054	24.97	-	-
Sulphur Sources								
Gy.	2166	2493	41.20	892.6	20.44	442.9	15963	1:3.31
Py.	2011	2300	40.98	824.0	20.26	407.5	14589	1:3.18
ES.	1859	2154	40.85	758.9	20.13	373.8	12847	1:2.90
C.D at 5%	38.11	32.90	0.116	7.77	0.042	19.34	-	-

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PHENOTYPIC STABILITY FOR POD CHARACTERS IN COWPEA

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ABSTRACT

Fifteen genotypes of cowpea were grown in two seasons and at three levels of phosphate fertilizer to study the phenotypic stability for pod yield and related pod characters. Presence of genotype × environment interaction was observed for all the six characters studied. The genotypes Sel 2-1, IIHR 61-B, Sel-263, DCP-120 and Faizabadi L-1 were found to be good performers and showed stability for a number of traits. These genotypes can be further utilized in cowpea breeding programs.

Key words : Cowpea, phenotypic stability, pod characters.

The importance of cowpea (*Vigna unguiculata* (L.) Walp) as a protein-rich vegetable crop in the tropical and sub-tropical areas in well recognized. Cowpea cultivation in quite extensive all over our country during summer and rainy season. A number of varieties of cowpea are available for cultivation, though their adaptability across zones and/or seasons have not been tested. The present investigation has been carried out to study the phenotypic stability of some cowpea genotypes over seasons and artificially created environments for response to phosphatic fertilizer.

MATERIALS AND METHODS

Fifteen genotypes of cowpea were grown in two seasons (summer and kharif, 1996) under three levels of phosphate fertilizer (40, 60 and 80 kg P_2O_5/ha) to comprise the created environments. The experiment was laid out in rbd with 3 replications. Each net plot measured 2.7 × 1.5 m and plant spacing of 45 × 30 cm was maintained. Ten random plants were selected per plot to record data on pods/cluster, pods/plant, pod length (cm), pod diameter (cm), pod weight (g) and pod yield/plant (g). Statistical analysis for stability was done following Eberhart and Russell (1966).

RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences among the genotypes and environments for all the characters studied suggesting presence of variation among genotypes as well as environments. Mean squares due to environment (linear) were highly significant for all the characters indicating differences between environments and their considerable influence on all the characters studied. Linear component of g×e interaction was significant for pod diameter, pod weight and pod yield/plant indicating that differences among regression coefficients pertaining to various genotypes on the environmental mean were real for these traits. Sanghi and Kandlkar (1983), Singh and Debas (1990), Kandasamy et al. (1990), Singh and Singh (1991), reported highly significant g × e interaction for various characters in cowpea.

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The mean (X), regression coefficient (bi) and deviation from regression (S^2d) for all thepod characters and pod yield per plant are presented in Table 1. According to Eberhart and Russell (1966) a stable variety is one which shows regression value equal to unity (bi=1) and minimum deviation from regression close to zero ($S^2d=0$). The bi and S^2d values of each genotype were considered together for deciding the stability of the genotype. Genotypes with non-significant deviation along with high mean performance were considered to be the most stable genotypes.

Pods/cluster : The number of pods/cluster varied from 3.8 (Sel 2-1) to 1.7 (DCP). The genotype Sel 2-1 produced the maximum number of pods/cluster and exhibited regression value around one (bi = 1.11) and non-significant deviation from regression value close to zero. It was the most stable genotypes for pods/ cluster along with Pusa Komal. The genotypes Sel-263, Faizabadi L-1 and IIHR 61-B showed stability in spite of their low response. Eight genotypes were found unstable for pods/ cluster.

Pods/plant : The mean number of pods/plant ranged from 44.3 (IIHR 61-B) to 24.4 (Pusa Dofasli). Only Sel-16 was found stable as it was above average in performance and response for pods/plant. The genotypes IIHR 61-B, Sel 2-1 and Pusa Komal, although showing good performance, were found unstable due to higher values of regression and deviation from regression. Similarly genotypes VS-389, Sel-263, Faizabadi L-1 and DCP-124 recorded more pods/plant above population mean but were unstable due to low average response and higher values of deviation from regression.

Pod length :.The range of mean apdo length varied from 31.7 cm (DCP 120) to 20.7 cm (Pusa Dofasli) The genotypes DCP-122 and VS-389 produced longer pods and showed good stability. The genotypes Sel 2-1 and DCP-121 showed high performance ad response but were found having average stability. The genotypes Faizabadi L-1 and Sel-263 although having longer pod length were found unstable due to their significant deviation from regression.

Pod diameter : Pod thickness varied from 1.04 cm (DCP 120) to 0.64 cm (Pusa Dofasli). The genotypes DCP 120 and Set 16 were highly stable for pod diameter. DCP-120 produced the fleshiest pods with highest pdo diameter among the genotypes tested. Sel 2-1 and Faizabadi L-1 showed high performance and stability but were below average in response. Seven genotypes were found unstable for pod diameter.

Pod weight : The mean pod weight ranged from 10.1g (Sel 2-1) to 5.5 g (Pusa Dofasli) Sel-263 showed stability for pod weight over all the environment tested. The genotypes DCP-120, Sel 2-1, VS-389 showed high performance but were below average in response. High performance was

Table 1. Stability parameters for pod characters in cowpea

Genotypes	Pod/cluster			Pods/plant			Pod length (cm)			Pod diameter (cm)			Pod weight (g)			Pod yield/plant (g)		
	X	bi	S^2d	X	bi	S^2d	X	bi	S^2d	X	bi	S^2d	X	bi	S^2d	X	bi	S^2d
Sel-11	1.9	0.073	0.026**	32.8	1.506	1.511	20.7	0.993	-0.162	0.81	1.778	0.001*	6.7	0.710	-0.080	217.9	0.446	-166.584
Pusa Tituraj	3.2	1.790	0.012*	35.3	0.448	-0.356	23.9	0.659	0.115	0.72	1.433	0.002*	7.7	1.526	0.150	272.9	1.411	194.526
DCP-125	1.8	0.760	0.006*	30.4	1.040	2.503	29.3	1.168	0.071	0.78	1.100	-0.000	8.1	0.946	0.116	244.5	0.046	692.931**
Pusa Komal	3.4	1.174	0.002	38.4	1.570	4.628	24.9	0.911	0.010	0.81	1.233	-0.000	7.8	0.716	-0.004	296.6	0.437	-83.596
Sel 2-1	3.8	1.110	-0.003	43.9	1.716	-1.282	29.1	1.073	-0.241	0.94	0.567	-0.000	10.1	0.842	-0.065	440.9	1.016	-96.380
IIHR-61-B	3.3	0.827	-0.002	44.3	1.467	-1.812	26.4	0.866	-0.030	0.89	0.133	0.002*	9.9	2.215	-0.003	439.7	2.468	-90.099
DCP-124	2.1	1.144	-0.001	36.2	0.712	1.175	26.1	1.100	-0.016	0.93	0.644	-0.000	8.0	1.247	-0.108	290.8	1.350	73.431
DCP-120	2.0	1.764	0.053**	33.0	0.460	-1.398	31.9	0.740	0.138	1.04	1.111	-0.000	10.6	0.307	-0.050	348.8	0.544	-121.627
Pusa Dofasali	2.9	0.618	0.375**	24.4	0.734	10.093**	20.7	1.403	0.373*	0.64	1.478	0.001*	5.5	1.065	-0.039	135.1	1.031	-70.730
VS-389	3.5	0.871	0.007*	43.5	0.812	2.53	27.3	1.026	-0.047	0.89	0.222	0.003**	8.9	0.844	-0.129	389.0	1.350	-84.284
Sel-16	2.1	0.966	0.004	36.9	1.185	0.295	22.6	0.954	-0.023	0.85	1.178	-0.000	7.9	1.478	-0.124	292.0	1.193	-64.053
Sel-263	3.7	1.346	-0.002	42.3	0.507	1.844	28.8	1.560	5.316**	0.85	0.644	-0.000	10.1	0.989	-0.120	426.7	1.431	113.758
Faizabadi L-1	3.7	0.526	-0.003	39.0	0.765	-1.236	31.0	0.509	1.142**	0.92	0.356	-0.000	9.8	1.523	-0.072	376.9	1.686	-79.343
DCP-122	1.7	0.829	0.011**	28.0	1.005	-1.107	31.1	0.968	-0.085	0.86	1.844	0.002*	7.7	0.072	0.065	220.2	0.338	-105.894
DCP-121	1.7	0.496	0.009*	26.9	1.060	-1.434	31.4	1.074	-0.221	0.84	1.867	0.002*	7.9	0.527	0.012	216.5	0.251	-57.572
Mean	2.7	0.997		35.7	0.999		27.0	0.999		0.85	1.009		8.4	1.000		307.2		1.000
SE ±	0.08	0.615		0.78	0.593		0.36	0.246		0.01	0.365		0.15	0.212		7.86		0.215

* $p < 0.05$; ** $p < 0.01$

also observed in IIHR 61-B and Faizabadi L-1, but these genotypes showed above a average response and were unstable over environments.

Pod yield/plant : the range of pod yield/ plant varied from 440.9g (sel 2-1) t 135.1 g(Pusa Dofasli) Sel 2-1 produced the highest yield per plant, average response and stability over environments. The genotypes IIHR 61-B, Sel 263, VS 389 and Faizabadi L-1 showed high performance, above average response and nonsignificant deviation from regression. Similarly DCP-120 showed high performance and nonsignificant deviation from regression, but below average response. DCP-125 was the only unstable genotype showing significant deviation from regression.

Among the genotypes tested for their performance and stability over environments, Sel 2-1 showed high performance for yield and its attributing pod characters. It also showed above average response and stability for the characters studied. The other good genotypes identified as good performers and showing stability for a number of traits were IIHR 61-B. Sel 263, DCP-120 and Faizabadi L-1. Pusa Dofasli was the lowest yielding genotype and it was also unstable for a number for pod characters studied.

Since yield is governed by its component characters, stability for the yield attributing characters also contributes towards stability for yield. This was found true in the case of above genotypes, which showed high performance coupled with stability over environments. These genotypes can be exploited for improvement of yield and pod related characters in cowpea.

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EFFECT OF NITROGEN AND PHOSPHORUS ON THE PERFORMANCE OF HYBRID BRINJAL (*SOLANUM MELONGENA* L.)

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ABSTRACT

Four levels of nitrogen viz., 50, 100, 150 and 200 kg/ha along with 3 levels of phosphorus viz., 0, 50 and 100 kg/ha were tested in two brinjal hybrids viz., Pusa Hybrid-5 and Pusa Hybrid-6 during rainy season of 1996. Pusa Hybrid-5 exhibited significantly increased plant height, leaf area and fresh weight of shoot over the Pusa Hybrid-6. It also showed earlier maturity, longer crop duration and more marketable yield. Among different nitrogen levels, 150 kg N/ha resulted in maximum plant height, stem girth, leaf area and fresh and dry weight of shoot per plant. The effect of phosphorus or its interation with nitrogen did not influence above characters significantly. Both Pusa Hybrid-5 and Pusa Hybrid-6 resulted in maximum net profit of Rs. 72,349 per ha and Rs. 49,676 per ha, respectively at the nutrient combination of $N_{150}P_0$.

Key words : Nitrogen, phosphorus, brinjal.

In the last few years a large number of brinjal F_1 hybrids have been floated in the market mostly by private and a few by public sector institutions. The response of applied N and P has been studied by several workers in pure line varieties of brinjal (Mertia and Chauhan, 1970; Verma et al., 1974; Gupta and Rao, 1984; Srivastava and Singh, 1985 and Selvaraj and Ramamoorthy, 1990). However, so far authentic research based information on the production technology of hybrid brinjals is lacking. Presently the farmers are following the package of practices mainly suggested by the private seed companies but their fertilizer recommendations do not appear so practical and widely adaptable which are generally on higher side. In order to popularize the cultivation of F1 hybrids, a study was conducted to determine the optimum dose of nitrogen and phosphorus for economic yield of round and long fruited hybrid brinjals.

MATERIALS AND METHODS

The experiment was conducted at Horticultural Research Centre, Patharchatta of the G.B. Pant University of Agriculture and Technology during rainy season of the year 1996. The soil of the experimental site was sandy loam with pH 6.53 and available

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NPK 284.65, 77.16 and 241.85 kg/ha, respectively. The experiment was laid out in factorial randomized block design with three replications. The treatments comprised of 2 hybrid varieties viz., Pusa Hybrid-5 (long fruited) and Pusa Hybrid-6 (round fruited) with 4 levels of nitrogen (50, 100, 150 and 200 kg/ha) and 3 levels of phosphorus (0, 50 and 100 kg/ha). A uniform dose of potassium and zinc sulphate @ 50 kg/ha and 25 kg/ha respectively, were applied as basal. Half of the nitrogen and full dose of phosphorus were applied as basal at transplanting through urea and diammonium phosphate. The rest half of nitrogen was top-dressed in two splits at 30 days and 50 days after transplanting. The seedling of 28 days age were transplanted at 75 cm × 60 cm spacing on 19th July. The observations were recorded on various growth, maturity and yield attributes. The production economics was calculated based on variable costs.

RESULTS AND DISCUSSION

Growth and maturity

The final plant height, stem girth, mean leaf area, fresh weight of shoot and root/plant and days to final harvest were maximum at 150 kg N/ha, which however, was at par with highest level of 200 kg N/ha but differed significantly with the lower 2 nitrogen levels with respect to all these growth characters (Table 1). In case of days to final harvest, the N_{150} was at par with N_{100} also, but with respect to dry matter accumulation in shoots, the N_{150} proved significantly superior than all the rest treatments. Repka (1979) and Subramanian et al. (1993) also reported that plant height increased successively with each increment of nitrogen level from 0-150 kg/ha. The effect of phosphorus levels was not found to be significant. Among the varieties, Pusa Hybrid-5 showed significantly higher plant height, leaf area, fresh weight of root and shoot/plant, lesser number of days to first picking and longer crop duration compared to the round fruited Pusa Hybrid-6. Kalda and Gupta (1996) also reported that the long fruited Pusa Hybrid-5 matured earlier than round fruited Pusa Hybrid-6.

Yield and yield attributes

The nitrogen level at 150 kg/ha being at par with 200 kg/ha, produced maximum number and weight of fruits per plant, as also the marketable and total per hectare yield. The unmarketable yield showed parity in case of all the 3 higher nitrogen levels. Vigorous vegetative development coupled with superior yield attributes were bound to produce greater yield at this nitrogen level (N_{150}). Lal and Singh (1976) also found best results when the hybrid of cross ($T_2 \times T_3$) was supplied with 160 kg N/ha. Gupta and Rao (1984), Selvaraj and Ramamoorthy (1990) and Subramanian et al. (1993) also indicated higher brinjal yields at same nitrogen dose, i.e., N_{150}. The nonsignificant response of brinjal crop to phosphorus application occurred probably due to the higher initial content of phosphorus in the experimental soil.

The number of fruits per plant, mean per fruit weight, dry matter content in fruits, specific gravity and the

Table 1. Effect of variety and NP nutrition on growth and maturity of brinjal hybrids

Treatment	Mean plant height (cm)	Branches/ plant	Mean stem girth (cm)	Mean leaf area (cm)	Fresh weight of shoots/ plant(g)	Dry matter % in shoots	Fresh weight of root/ plant(g)	Dry matter % in roots	Days to first picking	Days to final harvest
Variety										
Pusa Hybrid-5	113.43	6.93	7.68	152.40	500.61	26.19	71.72	44.47	69.77	173.19
Pusa Hybrid-6	101.46	6.70	7.86	132.51	452.25	27.31	58.44	42.55	76.44	168.66
S.Em.±	1.20	0.19	0.13	2.54	12.07	0.18	2.80	0.99	0.53	1.21
C.D. at 5%	3.41	NS	NS	7.45	34.37	0.53	7.99	NS	1.51	3.45
Nitrogen levels										
N_{50}	103.31	7.02	7.46	128.68	397.44	25.44	57.77	43.55	74.77	166.94
N_{100}	104.85	6.88	7.53	140.10	459.27	26.35	58.72	45.05	72.00	170.66
N_{150}	111.42	7.10	8.08	151.67	531.22	28.21	74.55	43.11	72.55	173.55
N_{200}	110.20	6.42	8.00	149.38	517.77	27.00	69.27	42.33	73.11	172.55
S.Em.±	1.67	0.27	0.18	3.60	17.07	0.26	3.97	1.39	0.75	1.71
C.D. at 5%	4.83	NS	0.53	10.53	48.60	0.75	11.31	NS	NS	4.88
P_2O_5 levels										
P_0	107.35	7.12	7.85	138.65	499.54	26.53	68.70	42.16	73.66	169.70
P_{50}	108.46	6.81	7.83	143.86	470.70	26.62	63.95	45.95	73.25	171.33
P_{100}	106.53	6.63	7.62	144.86	459.04	27.09	62.58	42.41	72.41	171.75
S.Em.±	1.47	0.23	0.16	3.12	14.78	0.23	3.44	1.21	0.64	1.48
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

unmarketable yield varied significantly owing to varieties. Long fruited Pusa Hybrid-5 produced more number of fruits/ plant but the round fruited Pusa Hybrid-6 outweighed it with wide margin with regard to mean per fruit weight (Table 2). Although the marketable and total yields were similar in both the hybrids but the round fruited Pusa Hybrid-6 produced higher unmarketable yield primarily due to the attack of fruit rot.

Economics

Both the hybrids exhibited maximum net return and cost benefit ratio with the application of nitrogen @ 150 kg/ha without phosphorus. However, overall assessment of the performance of hybrids at different nutrient levels indicated that long fruited Pusa Hybrid-5 supplied with 150 kg N/ha proved most rewarding giving the maximum C : B ratio of 4.51.

Table 2. Yield and yield attributes as influenced by different treatments

Treatment	No. of fruits/ plant	Yield/ plant (kg)	Per fruti weight (g)	Dry matter in fruit (g)	Specific gravity	Yield (q/ha)		
						Marketable	Unmaarketable	Total
Variety								
Pusa Hybrid-5	25.44	2.15	84.13	7.18	0.6593	478.76	108.59	478.76
Pusa Hybrid-6	13.64	1.98	145.52	6.19	0.6401	443.52	159.71	443.52
S.Em.±	0.57	0.07	2.43	0.14	0.0066	14.99	5.80	14.99
C.D. at 5%	1.64	NS	6.93	0.41	0.0189	NS	16.50	NS
Nitrogen levels								
N_{50}	17.00	1.61	104.97	6.65	0.6707	360.36	102.09	360.36
N_{100}	18.20	1.91	111.67	6.63	0.6393	428.26	129.78	428.26
N_{150}	22.30	2.43	121.22	6.75	0.6507	542.05	152.54	542.05
N_{200}	20.66	2.30	121.44	6.70	0.6380	513.88	152.18	513.88
S.Em.±	0.81	0.09	3.44	0.20	0.0094	21.20	8.20	21.20
C.D. at 5%	2.32	0.27	9.80	NS	NS	60.35	23.34	60.35
P_2O_5 levels								
P_0	19.93	2.15	117.79	6.55	0.6622	480.68	136.07	480.68
P_{50}	19.51	2.01	111.77	6.72	0.6445	448.19	129.86	448.19
P_{100}	19.19	2.04	114.92	6.79	0.6423	454.55	136.51	454.55
S.Em.±	0.70	0.08	2.98	6.17	0.0081	18.36	7.10	18.36
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Production economics of different treatments based on variable costs

Treatment	Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net Return (Rs./ha)	Cost: Benefit ratio
Pusa Hybrid-5					
$N_{50}P_0$	320.3	19755	64072	44317	3.24
$N_{50}P_{50}$	281.7	20179	56340	36161	2.79
$N_{50}P_{100}$	278.2	21062	55646	34574	2.64
$N_{100}P_0$	309.9	20086	61988	41902	3.08
$N_{100}P_{50}$	314.0	20954	62812	41858	2.99
$N_{100}P_{100}$	341.1	22236	68238	46052	3.06
$N_{150}P_0$	500.6	22186	100136	72349	4.51
$N_{150}P_{50}$	402.5	22599	80508	57909	3.56
$N_{150}P_{100}$	408.4	23591	81682	58091	3.46
$N_{200}P_0$	398.8	22080	79766	57686	3.61
$N_{200}P_{50}$	471.9	23632	94396	70764	3.99
$N_{200}P_{100}$	413.1	23918	82636	58718	3.45
Pusa Hybrid-6					
$N_{50}P_0$	219.8	19006	43960	24954	2.51
$N_{50}P_{50}$	245.3	20133	49072	28939	2.43
$N_{50}P_{100}$	204.1	20726	40822	20096	1.96
$N_{100}P_0$	293.9	20761	58794	38033	2.83
$N_{100}P_{50}$	241.6	20823	48332	27509	2.32
$N_{100}P_{100}$	275.4	22431	55090	32659	2.45
$N_{150}P_0$	356.7	21664	71340	49676	3.29
$N_{150}P_{50}$	347.4	22442	69490	47048	3.09
$N_{150}P_{100}$	321.4	23282	64284	41002	2.76
$N_{200}P_0$	342.8	21994	68562	46568	3.11
$N_{200}P_{50}$	241.2	22619	48256	26237	2.19
$N_{200}P_{100}$	302.0	23328	60414	37086	2.58

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EFFECT OF NITROGEN AND SULPHUR LEVELS ON THE OIL AND PROTEIN YIELD OF MUSTARD (*BRASSICA JUNCEA*)

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ABSTRACT

A field experiment was conducted during the winder (rabi) seasons of 1996-97 and 1997-98 at Kumher, Bharatpur to study the effect on nitrogen and sulphur levels on the oil and protein yield of mustard. Nitrogen fertilization upto 40 kg ha^{-1} had some favourable effect on oil content of mustard seed, beyond which a progressive reduction was noted. The oil yield, protein content and protein yield increased significantly with the increasing levels of nitrogen and sulphur. The realistic and trust worthy combined level of nitrogen and sulphur was 80 kg N + 60 Kg S ha^{-1} for optimum production of oil and protein in mustard duri..g both the years as well as in pooled analysis.

Key words : Nitrogen, sulphur levels, protein, mustard.

Rapeseed mustard group of oil seeds is the second most important after groundnut, contributing 28.4 percent (1999-2000) of the total oil production in India. The consumption of edible oil in the country is 7.2 Kg per head per annum compared to 11.0 kg of world average. The total requirement of edible oils at present level of population is about 5.5 million tonnes while availability is only 4.3 million tonnes (anonymous, 1997). One of the important ways for increasing productivity of mustard is improving crop nutrition through balanced fertilization. An adequate supply of nitrogen result in vigorous growth and dark green colour of the plant. The role of sulphur in the formation of sulphur containing amino acids and synthesis of proteins, chlorophyll and oil in mustard.

MATERIALS AND METHODS

A field experiment was conducted during winter of 1996-97 and 1997-98 at Agricultural Research Sub-Station Kumher, Bharatpur. The soil was loamy in texture, having 182, 43 and 355 kgha^{-1} available N, P and K respectively. The sulphur level of the experimental site was 6.20 ppm which was quite below the critical limit for mustard crop. The experiment was laid out in split plot design, N in main plot and S in sub plot with four replication. The treatment consist of 5 levels of N (20, 40, 60, 80 and 100 Kgha^{-1}) and 5 levels of S (0, 20, 40, 60 and 80 Kgha^{-1}). Urea and Gypsum was used as source of N and S respectively. Varuna (T-59) mustard was sowing using 5 Kgha^{-1} seed rate as a spacing of 40 cm × 10 cm. and one irrigation at 45 days after sowing was given. Oil percentage in seed was determined by nuclear magnetic resonance, as suggested by Tiwari et al. (1974). Oil yield (Kg ha^{-1}) was worked out on the basis of oil percentage in seed and seed yield ha^{-1}, protein content in seed was determined directly by an instrument known as NIR working on the principle of near infrared reflectance. The protein production was estimated by multiplying the seed yield ($Kgha^{-1}$) with the protein content (%) and expressed in ($Kgha^{-1}$).

RESULTS AND DISCUSSION

Effect of nitrogen

The successive increase in N levels upto 40 $kgha^{-1}$ had some favourable effect on oil content of mustard seed beyond which a progressive reduction in oil content was noted during both the seasons of study (Table 1). Thus when compared with the two seasons pooled oil content of 39.61 percent recorded under 40 Kg N ha^{-1}, application of N @ 60, 80 and 100 Kg ha^{-1}, decreased it significantly by 0.76, 2.53 and 3.15 percent, respectively. Nitrogen fertilization to the crop improved the oil production significantly during both the years of study as well as in the pooled analysis. A perusal of data (Table 1) revealed that nitrogen fertilization to mustard had significant effect on protein content of seed during 1996-97 and pooled analysis. Protein content of seed increased progressively with every increase in N levels from 20 to 100 kg ha^{-1}. While protein production increased with increasing N levels significantly upto 80 Kg N ha^{-1}.

Oil content of seed decreased with higher levels of N, probably due to dilution effect as evidenced from bolder seed recorded at higher N levels besides insignificant role of N in oil synthesis. This may be due to the fact that increasing availability of N increased the proportion of proteinous substance in the seeds. Findings of Trivedi et al. (1995), Dalai et al. (1996) and Singh and Kumar (1996) also provided support to the findings of present investigation, who also reported improvement in protein content with protein and oil yields and reduction in oil content of seed due to N fertilization.

Effect of sulphur

Increasing levels of sulphur from 20 to 80 $Kgha^{-1}$ enhanced the oil yield and protein content in the seed. Similar trend was also estimated with oil and protein yield. Since protein content of seed is essentially a manifestation of N content increased Seed N content due to Sulphur fertilization in higher protein content (Table 1). The significant increase in oil production under Sulphur fertilization could be ascribed to significant increase in seed yield and oil content. The increase in oil content under significant increase in seed yield and oil content. The increase in oil content under influence of S fertilization seems to be due to increased S content in seed, which has a significant role in overall biosynthesis of oi. Findings of Jain et al. (1996) and Sandhya and Gupta (1998) in mustard also provided support to findings of the present investigation.

Economics

Oil yield response (Table 2) of mustard

Table 1. Effect of nitrogen and sulphur on oil and protein production of mustard

Treatment	Oil Content (%)			Oil Production (Kgha^{-1})			Protein content (%)			Protein Production (Kgha^{-1})		
	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled
Nitrogen (Kg ha^{-1})												
20	39.39	39.62	39.50	466	471	468.5	19.16	18.73	18.95	229	223	226
40	39.48	39.75	39.61	629	626	627.8	19.62	19.12	19.37	311	300	305.5
60	39.29	39.33	39.31	729	716	717.5	20.05	19.53	19.79	367	356	361.5
80	38.48	38.79	38.63	743	745	774.0	20.38	19.94	20.16	393	383	388.0
100	38.34	38.46	38.40	723	724	723.5	20.87	20.34	20.60	394	383	388.5
C.D. (P=0.05)	0.285	0.447	0.294	32.5	20.5	20.9	0.84	NS	0.79	18.02	35.33	21.20
Sulphur (Kgha^{-1})												
0	38.64	38.71	38.68	530	526	528.0	19.68	19.25	19.46	269	261	265.0
20	38.82	39.03	38.92	624	623	623.5	19.89	19.40	19.65	321	312	316.0
40	38.96	39.22	39.09	688	689	688.5	20.07	19.58	19.82	356	346	351.0
60	39.14	39.45	39.29	716	723	719.5	20.21	19.68	19.94	375	363	369.0
80	39.42	39.54	39.48	722	721	721.5	20.23	19.75	19.99	373	363	368.0
C.D. (P=0.05)	NS	0.430	0.356	35.73	28.07	22.49	NS	NS	NS	25.5	27.5	18.56

Table 2. Response functions of nitrogen and sulphur application to mustard oil production

Year	Response equation	Most profitable rate(kg/ha^{-1})	Oil yield at most profitable rate(kg/ha^{-1})
Nitrogen			
1996-97	$Y = 251.42 + 12.39x - 0.077x^2$	79.08	750.24
1997-98	$Y = 260.62 + 12.03x - 0.074x^2$	79.83	749.14
Pooled	$Y = 256.02 + 12.21x - 0.075x^2$	79.38	749.03
Sulphur			
1996-97	$Y = 529.48 + 5.46x - 0.038x^2$	70.11	724.43
1997-98	$Y = 524.64 + 5.77x - 0.041x^2$	86.65	725.91
Pooled	$Y = 526.90 + 5.63x - 0.040x^2$	69.21	724.95

to varying levels of nitrogen and Sulphur was quadratic during both the years as well as in pooled analysis. The most profitable levels of N and S in 1996-97 & 1997-98 were worked out to be 79.08, 79.83 and 70.08, 68.65 kg ha^{-1} respectively.

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BIOCHEMICAL BASIS OF RESISTANCE IN PIGEONPEA TO POD FLY [*MELANAGROMYZA OBTUSA* (MALL.)]

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ABSTRACT

Podfly, *Melanagromyza obtusa* (Mall.) is a major pest of long duration pigeonpea (*Cajanus cajan* (L.) Millsp.] in India. As the chemical control of the podfly is difficult and costly, a search for biochemical basis of resistance in pigeonpea to podfly is being undertaken at Varanasi, India. Thirty diverse cultivars were used to determine the role of total sugar and total phenol contents in podwall to podfly infestation in long pigeonpea cultivars. All the cultivars are divided into two broad group on the basis of per cent pod damage by podfly. The findings indicated that the higher degree of defence mechanism against the podfly infestation is due to the presence of higher percentage of total phenols and lower percentage of total sugar contents in podwalls.

Key words : *Cajanus cajan*, pod fly, resistance, biochemicals.

Pigeonpea (*Cajanus cajan* (L.) Millsp.] suffere large losses to many insect pests but particularly to the pod borer and podfly. Podfly, *melanagromyza obtusa* (Mall.) is an serious pest of long duration pigeonpea causes greater damage in Central & Northern parts of India (Reddy *et al.*, 1981). The pod damage caused by podfly on pod basis may be high as 100 per cent (Gangrade 1963) and upto 20 pr cent on grain basis (Sithanantham, *et al.*, 1987). Oviposition occurred on the inner surface of the podwall of green pods and the ovipositional behaviour of the pod fly it is seen that morphological, anatomical and biochemical characters/constituents of podwalls effect the ovipositional behaviours. Therefore, the investigation were carried the biochemical basis of resistance in long duration pigeonpea podwall to pod fly infestation.

MATERIALS AND METHODS

The experiment was carried out during Kharif, 1994-95 to Kharif, 1996-97, at Agricultural Research Farm, Banaras Hindu University, Varanasi, in a randomized block design with three replications. Thirty diverse cultivars were divided into two broad susceptibility groups, based on pod damage by pod fly as detailed in Table 1. The data were recorded on ten randomly tagged plant from each of the cultivars. The per cent pod damage by pod fly at maturity were recorded. The presence of the pin head 'exit hole' indicated the susceptible to pod fly. Then mature pods from each plants were randomely selected for the estimation of total sugar by "phenol sulphuric method" of Dubios *et al.*, (1951) and total phenols by :Folin ciocalteau method" of Malik and SINGH (1980).

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RESULTS AND DISCUSSIONS

The per cent pod damage by podfly *M. obtusa* (Mall.) is maximum in susceptible group second cultivars namely Bahar 971.93), T$_7$ (69.08) and ICPL 5036 (65.94%) and minimum pod damage in susceptible group first cultivars (Table 1). Similarly, the total sugar content in podwalls were maximum in suceptible group second cultivars and minimum in susceptible group first. The total phenols in podwalls were maximum in susceptible group first and minimum in suceptible group second. The total phenols in podwall showed the reverse trend form total sugar contents in podwalls and podfly infestation. The presence of higher amount of total sugar and lower amount of total phenols in podwalls in susceptible group second (e.g. Bahar) might be the reason for their higher susceptibility to podfly, *melanagromyza obtusa* (Mall.). Dass and Odak (1987) and Sithananthaim, *et al.*, (1983) also reported that higher amount of total sugar and lower amount of

Table 1. The per cent pod damage by podfly and biochmical contents in podwalls of pigeonpea strains (means of the three replications)

Strains/Cultivars	Percent pod damage by pod fly	Total sugar (%)	Total phenols (%)
Susceptible group first (<50% pod change by pod fly) i.e. resistant			
1. PDA 93-IE	26.22	4.91	2.95
2. PDA 89-2E	33.08	5.20	3.62
3. PDA 88-2E	25.70	4.81	3.02
4. MA$_2$	31.78	4.91	2.80
5. SL 12-3-1	26.73	4.30	2.60
6. SL 21-1-3	28.08	5.47	2.96
7. SL 21-6-2	28.07	5.61	2.53
8. SL 21-9-2	29.91	5.31	2.70
9. SL 22-2-3	27.55	4.95	2.70
10. ICP 810-5-S$_1$	26.04	4.56	1.80
Susceptible group second (>50% pod damage)			
1. Bihar	71.93	6.59	1.26
2. ICPL 5036	65.94	6.11	1.39
3. T$_7$	69.08	6.80	1.30

total phenols in podwalls increased the rate of podfly infestation. Presence of higher amount of total phenols in podwalls in susceptible group first (e.g PDA 88-2E) might be the reason for less pod damage by podfly. The present findings agree with these earlier reporters indicating a high degree of defence mechanism involved due to the increase the total phenols and decrease the total sugar contents in podwalls to podfly in susceptible group first (e.g. PDA 88-2E etc.).

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HETEROSIS IN RICE

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ABSTRACT

In a 7x7 diallel cross study, heterosis over better parent was maximum for grains/panicle grain weight/panicle and yield/plot in the crosses Vikas x Ratna and Sasyashree x Kanak Maximum heterobeltiosis fro 100-grains weight was observed was exhibited by the cross Chambal x IR-64. In general, crosses showing high heterosis also showed high inbreeding depression

Key words : Heterosis, inbreeding depression, rice, quantitative characters.

Exploitation of hybrid vigour is considered to be one of the outstanding achievements of plant breeding. To know the potential of crosses in a crop, the study of the magnitude and direction of heterosis is an important aspect. The availability of cytoplasmic male sterility as well as fertility restoring systems, vegetative nature of propagation and the hybrid rice technology developed by China and I.R.R.I, The Philippines have attracted much attention in research on heterosis breeding rice. Study of heterosis and inbreeding depression will have direct bearing on the breeding methodology to be employed for varietal improvement. Therefore, an attempt was made to measure the extent of heterosis and inbredding depression in rice (*Oryza sativa* L.).

MATERIALS AND METHODS

The material comprised seven genetically diverse cultivars. Sasyashree, Chambal, Haya Vikas, Ratna, Kanak and IR64. The seven parents, 21 F_1 and 21 F_2 were evaluated in 1998 at Agricultural Research Station, Kota in a randomised block design with three replications in plots consisting of single rows of parent and F_1 and three rows of F_2. The three meter long rows were planted 20 cm apart keeping plant to plant distance at 15 cm. Ten plants both in parents and F_1 and 20 plants in F_2 were randomly selected to record observation on grains/panicle, grain weight/ panicle and 100-grain weight. Yield was recorded on plot basis. Magnitude of heterosis over better parent and inbreeding depression form F_1 to F_2 were calculated.

RESULTS AND DISCUSSION

The data for the performance of hybrid with regard to mean of better parent and inbreeding depression from F1 to F2 generation for four character are presented in Table 1.

Grains/panicle

Heterosis over better parent ranged from -1 6.15 per cent in Sasyasree x Jaya to 50.89 per cent in Vikas x Ratna. Eight crosses exhibited significant positive heterobeltiosis. Three crosses other than the cross Vikas x Ratna (50.89%) which higher magnitude of better parent heterosis were Chambal x Vikas (21.04%) Sasyasree x Kanak (19.59%) and Jaya x Vikas (13.09%). Eleven crosses showed significant positive inbreeding depression.

Grain weight/panicle

The estimates of heterosis over better parent ranged form 9.32 per cent (Ratna x IR-64) to 55.15 per cent (Vikas x Ratna). Nine crosses exhibited significant positive heterobeltiosis of this character. Thirteen crosses showed significant positive inbreeding depression. The cross Vikas x Ratna showing maximum better parent heterosis also exhibited maximum inbreeding depression.

100-grain weight

Nine crosses possessed significantly higher estimates of heterobeltiosis ranging form 2.06 per cent in Sasyasree x IR-64 to 19.65 per cent in Ratna x Kanak. The cross Chambal x Vikas showed maximum negative heterobeltiosis. Fourteen crosses exhibited significant positive inbredding depression.

Yield/plot

Significant positive heterobeltiosis ranging from 6.60 per cent (Jaya x IR-64) to 64.62 per cent (Vikas x Ratna) were obtained for thirteen crosses. The other best cross which showed significant high heterobeltiosis were Sasyashree x Vikas (32.97%) and Ranta x Kanak (29.07%). Maximum significant negative heterobeltiosis was observed for the cross Chambal x IR-64 (-15.94%). All the crosses except Kanak x IR-64 showed significant positive inbreeding depression. Maximum inbreeding depression was observed in he cross Vikas x Kanak (21.49%).

It is obvious the results that cross showing maximum heterosis for grain yield/plot also had significant high heterotic effect for some yield components. Similar findings have been reported by Shaalan (1975), Yap and Chang (1976) and Singh *et al* (1980). A close relationship between heterotic response and inbreeding depression (i.e. crosses showing high heterosis also showed high inbreeding depression), suggested the importance of non-additive gene action in rice. Similar observations were made by sodani and Bhatnagar (1990) and Anandakumar (1995) in Sesame. However, there were certain exceptions, the crosses Ratna x Kanak, Jaya x IR-64 and Sasyashree x IR-64 had 29.07, 23.18, 10.43 and 2.06 per cent heterobeltiosis but only 8.15, 2.35, 3.06 and 0.69 per cent inbreeding depression for yield/plot, grain weight/panicle, grains/panicle and 100-grain weight, respectively. The increased vigore of the F_1s in such cases in expected to be mainly due to accumulation of favourable additive and

Table 1. Better parent heterosis (BP) and inbreeding depression (ID) for yield related quantitative characters in rice

Cross	Grains/panicle		Grain weight/panicle		100-grain weight		yield/plot	
	BP	ID	BP	ID	BP	ID	BP	ID
1x2	2.42	3.46	15.65**	4.25*	0.00	1.25	26.47	11.09**
1x3	-16.15**	0.89	-19.05**	-2.21	-3.77**	3.05	-13.27**	20.78**
1x4	4.29	9.22**	17.71	15.35**	14.19**	7.46**	32.97**	19.23**
1x5	-16.4**	-0.75	-25.24**	7.96*	7.33**	7.59**	-6.18*	6.64*
1x6	19.59**	8.06**	25.26**	4.62**	5.47**	-1.37	40.89**	16.77**
1x7	-11.72**	12.88**	-18.87**	7.71*	2.06*	0.69	-14.08**	17.52**
2x3	5.98*	1.40	16.98**	10.12**	7.80**	4.79**	35.80**	19.08**
2x4	21.04**	12.56**	-5.69**	8.63*	-13.66**	1.65	30.80**	16.63**
2x5	-6.56*	1.52	-14.09**	7.84*	-7.21**	5.53**	-1.79	8.89**
2x6	-14.58**	-1.98	-28.93**	-3.07	-9.12**	2.89*	-12.82**	18.78**
2x7	-8.88	8.10**	23.32**	6.77*	-9.99*	0.89	-15.94**	13.07**
3x4	13.09**	5.15*	-5.63**	4.18	-11.56**	1.70	38.52**	17.32**
3x5	-1.08	6.54*	-27.24**	0.99	-9.36**	3.08**	-8.89**	17.16**
3x6	1.29	1.87	-5.80*	6.99*	-5.80**	3.67**	13.34**	16.72**
3x7	10.43**	3.06	-4.30	6.91*	-8.90	6.44**	6.60*	17.23**
4x5	50.89**	12.45**	55.15**	23.25**	-9.75**	4.94**	64.62**	13.78**
4x6	-5.49	5.43*	16.40**	10.48**	10.23**	4.23**	20.23**	21.49**
4x7	9.89**	10.54**	26.96**	8.22**	3.08*	5.30**	25.59**	13.23**
5x6	11.01**	7.73**	23.18**	2.35	16.95**	2.58*	29.07**	8.15*
5X7	-8.93**	1.88	9.32*	3.20	6.38**	2.31	12.41**	20.41**
6x7	-9.14**	-6.75*	-7.58*	-1.06	0.17	-0.50	0.08	5.08

1 = Sasyashree, 2 = Chambal, 3=Jaya, 4=Vikas, 5=Ratna, 6=Kanak, 7=IR-64

*, **Significnat at 5 and 1 per cent, respectively.

epistatic genes, all being fixable. Such crosses are expected to throw desirable segregants which may be handled through pedigree method of selection.

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ESTIMATES OF VARIATION AND HERITABILITY OF SOME QUANTITATIVE CHARACTERS IN SUGARCANE

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ABSTRACT

Information in heritability and genetic variability was obtained for 12 characters in sugarcane. High heritability values were observed for all the characters. Yield/plot, cane length, extraction %, sucrose % 300 days, CCS% juice 300 days and CCS (kg/plot) had high genetic advance with high heritibality estimates, suggesting that there is scope for improvement in these characters through selection.

Key words : Variation, heritability, genetic advance, sugarcane, qnantitative characters.

In a crop improvement programme, the success depends upon the qnantum of genetic variability, heritability, genetic advance and other genetic parameters which are very essential for a breeder to choose good parent and to decide the correct breeding methodology for the improvement of the crop. Keeping this in view, the present experiment was designed.

MATERIALS AND METHODS

A set of 8 high yielding varieties of sugarcane was grown in a randomized block design with four replication during 1996-97 at Agricultural Station Ummedganj, Kota. CoLk 9110, CoS 91269, CoS 92263, CoS 91230, UP-39, CoS 767, CoLk 8102 and Co 1148 were planted under recommended fertility levels of 200:60:40 NPK kg/ha with a spacing of 90 cm between rows. Twelve buds were planted per metre row length. The plot size was 6 m x 4.5 m. Ten clumps were randomly selected in each plot and from replication for recording the data on 12 characters namely; millable cane/plot, cane length (cm), cane diameter (cm), Single cane weight (kg), extraction %, brix% 300days, sucrose % 300 days, CCS % juice 300 days, brix % 360 days, sucrose% 360. Yield and commercial cane sugar were computed on plot basis.

The analysis of variance was done as suggested by Panse and Sukhatme (1957). The phenotypic and genotypic coefficient of variations and heritability (broad sense) and genetic advance were computed (Singh and Chaudhary, 1985).

RESULTS AND DISCUSSION

A wide range of variability was observed in all the characters (Table 1). Statistical analysis revealed significant differences among the varieties for all the characters. The phenotypic and genotypic variance along with the heritability%, genotypic and phenotypic co-efficient of variations, genetic advance and genetic advance as percentage of mean are presented in Table 2.

The genotypic and phenotypic variances were higher for cane length, cane yield and millable cane/plot. Minimum value of these variance was obtained for single cane weight. The value for genetic coefficient of variation ranged from 2.81 (Sucrose%-360 days) to 7.91 (CCS% juice 300 days). High heritability values were obtained for all the characters. The range was from 59.00 to 94.22% High heritability generally enable the breeder to select clones on the basis of phenotypic expression. But Johnson *et al* (1995) pointed out that without genetic advance, the estimates of genetic heritability will not be of much value for selection on phenotypic performance. They suggested that genetic gain should also considered alongwith heritability estimates. Swarup and Chaugale (1962) also pointed out that high heritability is not always accompanied by high genetic advance. If heritability is mainly owing to non- additive gene effect, the expected genetic advance would be low, and if there is additive gene effect, a high genetic advance may be expected (Panse, 1978).

In pur study, high heritability values with high genetic advance wee obtained for yield/plot cane length, extraction%, sucrose %-300 days, CCS% juice 300 days and CCS (kg/plot). The results indicate that these characters can be improved through selection. This is to be expected as the varieties have been developed for high yield. Brix %-300 days, Brix % 360 days and single cane weight had moderate values for genetic advance, indicating the selection may help improve these characters. Sucrose % 360 days, millable cane/plot and cane diameter had low values of genetic advance, indicating that expression of these characters was conditioned by non- additive genes. Improvement in sugarcane can be possibly brought about through selection for yield/plot, cane length, extraction % and sucrose % 300 days and CCS% juice.

Table 1. ANOVA for yield and other quantitative characters in sugarcane

S.No.	Character	Mean sum of square	F value	CD (0.05)
1	Millable cane/plot	207.595	21.75**	5.41
2.	Cane length (cm)	539.415	21.29**	8.81
3.	Cane diameter (cm)	0.024	11.92**	0.07
4.	Single cane weight (kg)	0.006	23.21**	0.02
5.	Extraction %	45.819	12.00**	3.42
6.	bRIX % 300 days	3.723	4.42**	1.247
7.	Sucrose % 300 days	4.223	10.62**	1.10
8.	CCS% juice 300 days	2.450	9.34**	0.89
9.	Brix% 360 days	2.877	13.73**	0.80
10.	Sucrose% 360 days	0.891	5.49**	0.70
11.	Yield (kg/plot)	475.052	49.90**	5.40
12.	CCS (kg/plot)	8.033	8.80**	1.67

Table 2. Estimates of genetic parameters in sugarcane

S.No.	Character	Rang	Mean	Genetic variance	Phenotypic variance	GCV	PCV	Heritability (%)	Genetic advance	Genetic advance as % of mean
1.	Millable cane/plot	223-257	241.92	66.02	75.56	3.36	3.59	87.37	15.64	6.46
2.	Cane length (cm)	227.2-271.40	248.83	171.36	196.69	5.26	5.63	87.12	25.17	10.11
3.	Cane diameter (cm)	2.07-2.42	2.20	0.01	0.01	3.95	4.46	78.45	0.15	7.21
4.	Aingle cane weight (kg)	0.903-1.028	0.97	0.002	0.002	4.43	4.72	88.10	0.08	8.56
5.	Extraction%	47.81 - 59.62	54.12	14.00	17.82	6.93	7.81	78.58	6.83	12.64
6.	Brix% 300 days	16.09-20.42	18.24	1.07	1.57	5.68	6.88	68.15	1.76	9.66
7.	Sucrose % 300 days	13.20 - 17.56	15.79	1.27	1.67	7.15	8.19	76.23	2.03	12.85
8.	CCS% juice 300 days	8.75-12.08	10.79	0.73	0.99	7.91	9.23	73.55	1.50	13.97
9.	Brix % 360 days	18.29-21.57	19.96	0.89	1.10	4.73	5.25	80.94	1.74	8.75
10.	Sucrose % 360 days	16.30-18.44	17.57	0.24	0.41	2.81	3.62	59.99	0.78	4.47
11.	Yield (kg/plot)	197-10-238.90	218.21	155.18	164.69	5.71	5.88	94.22	24.90	11.41
12.	CCS (kg/plot)	23.10-29.43	26.51	2.37	3.29	5.81	6.84	72.24	2.69	10.17

GCV = Genetic coefficient of variation, PCV = Phenotypic coefficient of variation

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EFFECT OF PHOSPHORUS, SULPHUR AND BIO-FERTILIZERS ON PRODUCTIVITY AND SOIL FERTILITY OF FENUGREEK (*TRIGONELLA FOENUM-GRAECUM* L.) AND THEIR RESIDUAL EFFECT ON PEARLMILLET (*PENISETUM GLUCUM*)

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ABSTRACT

A field experiment was conducted at Agricultural Research Station, Fatehpur-Shekhawati (Sikar) Rajasthan, during 1997-98 and 1998-99. The soils of experimental field was loamy sand having available nitrogen 120.3 kg ha^{-1}, available phosphorus 24.5 kg ha^{-1}, available potassium 332.9 kg ha^{-1} and pH 9.21. The maximum yield of fenugreek was recorded with the application of 80 kg P_2O_5 ha^{-1}, 100 kg S ha^{-1} and seed treatment with *Rhizobium* + PBS. The residual effect of phosphorus and sulphur also increased the productivity of succeeding pearlmillet significantly but seed inoculation with bio-fertilizer crop. The highest mean returns (Rs. 12137) and B:C ratio (3.95) was recorded in fenugreek + pearlmillet cropping sequence with 80 kg P_2O_5 ha^{-1}, 100 kg S ha^{-1} and seed inoculation with *Rhizobium* + PSB in fenugreek. The fertilizer application at higher levels resulted in building up of the fertility of the soil.

KEY WORDS : Phosphorus, sulphur, bio-fertilizers, fenugreek, pearlmillet, soil fertility.

Fenugreek (*Trigonnella foenum-graecum* L.) popularly known by its vernacular name "Methi" is an important condiment crop grown in northern India during *rabi* season. The seeds are also used for medicinal purposes for chronic dysentery, diarrhea, chronic cough, enlargement of liver and spleen (Pruthi, 1979). Recent study indicates that fenugreek seed substantially contains the steroidal substance "diosgenin" which is used as a starting material in the synthesis of sex hormone as oral contraceptive (Elujoba and Harrdman, 1988).

In intensive agriculture involving high yielding varieties of crops has lead to heavy withdrawals of nutrients from the soil and fertilizer consumption remained much below compared to removal. This gap can be bridged by integrated nutrient supply approach only. Fenugreek being a legume crop does not require much nitrogen except in small quantities in the beginning of its life cycle. Phosphorus deficiency is usually the most important factor which is responsible for poor yield of legume crops on all soil types in areas where fenugreek traditionally grown. Phosphorus is not lost from soil as is known to leave residual effect. Slow mobility of applied phosphorus and its marked fixation results in low crop recoveries of the order of 20 to 25 per cent which calls for ways and means for its judicious use.

There is a need to explore other factors which can economise phosphorus use in crop rotation. Now-a-days traditional boundaries between primary and secondary nutrients are becoming narrower. Crop requires as much as sulphur as they do phosphorus and it can therefore be rightly called the forth major nutrient. Sulphur deficiency is increasing due to intensive cropping, use of high yielding varieties and continuous use of sulphur free high analysis fertilizers. Information on nutrient management on individual crops is available while on cropping system, it is lacking. Moreover, the single nutrient approach now a days has been replaced by multi-nutrient to provide balanced nutrients to bust up crop productivity and plant nutrient use efficiency. Besides, nutrient management in cropping system is more efficient and judicious than individual crop, as succeeding crop take care of the residual effect of nutrients, particularly phosphorus and some extent to sulphur. So much so multi-nutrient approach along with bio-fertilizers in a crop and its residual on succeeding crop seems to be rational at a time of high prices and short supply of chemical fertilizers. Keeping these consideration in view, the present field investigation was undertaken.

MATERIALS AND METHODS

A field experiment was conducted for a consecutive years (1997-98 and 1998-99) on loamy sand soils at Agricultural Research Station, Fatehpur-Shekhawati (Sikar) Rajasthan. The soil was low in organic matter (0.15%) and available N (120.3 kg ha^{-1}), medium in available P (10.7 kg P ha^{-1}), and high in available (332.9 kg ha^{-1}). The experiment consisted of 36 treatment combinations, comprising three levels of phosphorus (0, 40 and 80 kg P_2O_5 ha^{-1}), three levels of sulphur (0, 50 and 100 kg S ha^{-1}) and four levels of bio-fertilizers (Control, *Rhizobium*, PSB and *Rhizobium* + PSB). These treatments were evaluated under split plot design with three replications. Phosphorus and sulphur were allocated in main plots and bio-fertilizers in sub-plots. A uniform dose of nitrogen (31.3 kg ha^{-1}) was maintained and phosphorus and sulphur as per treatment was drilled manually through DAP and gypsum at the time of sowing. Inoculation of the seed with bio-fertilizers was also done as per treatment. The fenugreek variety RMt-1 was sown on first week of November, during both the years at a depth of 5 cm in row spaced at 30 cm using seed rate of 20 kg ha^{-1}. For residual study, the pearlmillet variety MH-179 was sown at a depth of 5 cm in a row spaced at 40 cm using seed rate of 4 kg ha^{-1}.

RESULTS AND DISCUSSION

Response of fenugreek to P,S and bio-fertilizes

The seed yield of fenugreek increased significantly with increasing levels of phosphorus up to 80 kg P_2O_5 ha^{-1} during both the years (Table 1). On an average application of 80 kg P_2O_5 ha^{-1} increased the seed yield by 24.89 per cent over control and 12.33 per cent over 40 kg P_2O_5 ha^{-1}. The results are in close conformity with the findings of Detroja *et al.* (1995) and Jat (1995). The significant increase in seed yield and yield attributes observed under phosphorus application seems to have resulted on account of improved nutritional condition inside the plant. A part of effect on increase in yield observed under phosphorus application might be assigned to improved root environment. Phosphorus fertilization markedly influenced the source indirectly by increasing the plant height and dry matter accumulation. Thus their culminated influence seems to have maintained balance source sink component to a large extent due to adequate mineral nutrition to the plant resulting in improved fenugreek yield (Nageswara Rao, 1992).

Sulphur application significantly increased the seed yield of fenugreek during both the years. Application of 100 kg S/ha increased the mean seed yield by 8.09 and 4.60 per cent during 1997-98 and 7.58 and 4.34 per cent during 1998-99 over control and 50 kg S ha^{-1}, respectively (Table 1). Sulphur plays vital role in improving vegetative structure and production of assimilate to fill economically important sink (Sacchidanand *et al.* 1980).

Seed treatment with bio-fertilizers significantly increased the seed yield of fenugreek during both the years. Seed treatment with PSB + *Rhizobium*, PSB alone and *Rhizobium* alone increased the mean seed yield by 3.67, 2.30 and 1.37 per cent over control (Table 1). This might be attributed to reducing P fixation by its chelating effect and also solubilized the fixed form of P leading to more uptake of nutrients. *Rhizobium* fixes the atmospheric nitrogen and helped in increasing the seed yield of fenugreek (Dubey, 1996).

Response of pearlmillet to residual P, S and bio-fertilizers

Residual effect to increased phosphorus increased the grain yield of pearl millet significantly across the years. Application of 80 kg P_2O_5 ha^{-1} in fenugreek increased the mean grain yield of pearl millet by 35.58 per cent over control. This might be ascribed to improvement in available nutrients in soil and their better absorption by plants.

Sulphur application to fenugreek significantly increased the grain yield of succeeding pearl millet significantly during both the years. Application of 100 kg S ha^{-1} significantly increased the mean grain yield of pearl millet by 9.83 and 5.43 per cent over control and 50 kg S ha^{-1}, respectively (Table 1). It might be possible that increased availability of sulphur to plants causes to extract other nutrients like phosphorus from soil to maintain their critical concentration or limit the potential hazards of excess concentration of other nutrients. Residual effect of seed inoculation with bio-fertilizers had no significant effect on grain yield of pearl millet during both the years.

Economics of fenugreek

Direct application of phosphorus, sulphur and bio-fertilizers to fenugreek significantly increased the net returns (Rs/ha) over control during both the years. There was no significant effect of phosphorus and sulphur application with regards to B:C ratio. Phosphorus application

@ 80 kg P_2O_5 ha^{-1} increased the net return by Rs. 3981 and 4138 during 1997-98 and **1998-99 over** control, respectively. **Application of 100** kg S ha^{-1} increased the **net return by Rs**. 1486 and 1426 during **1997-98 and** 1998-99 over control, respectively. The mean increase in net return was recorded with PSB + *Rhizobium* by Rs. 849, PSB alone by Rs. 535 and *Rhizobium* alone by Rs. 323 over control (Rs. 17043).

Economics of pearl millet

Residual effect of phosphorus and sulphur application significantly effected the net return and B : C ratio of the pearl millet. Residual effect of 80 kg P_2O_5 ha^{-1} increased the mean net return by Rs. 4513 over control (Rs. 8542) and B:C ratio was 3.68 whereas with control it was 2.41 only. Residual sulphur increased the mean return by Rs. 1296 with 100 kg S ha^{-1} over control. Residual effect of bio-fertilizers failed to effect the net return and B:C ratio of pearl millet significantly.

Change in soil fertility

The change in soil fertility status was assessed after harvest of each crop. Phosphorus application significantly increased the available phosphorus after harvest of fenugreek as well as after harvest of pearl millet during both the years. Application of 80 kg P_2O_5 ha^{-1} increased the mean available P_2O_5 by 47.96 and 15.83 per cent after harvest of fenugreek and 54.03 and 17.73 per cent after harvest of pearl millet over control and 40 kg P_2O_5 ha^{-1}, respectively. Though phosphorus had no significant effect on available N and S in soil after harvest of fenugreek as well as pearl millet (Table 2).

Sulphur application significantly increased the available sulphur in soil after harvest of fenugreek and pearl millet during both the years. Although sulphur had no significant effect on available N and P in soil (Table 2).

Seed treatment with *Rhizobium* and *Rhizobium* + PSB increased the available N (kg ha^{-1}) in soil by 3.50 and 4.78 per cent over control after harvest of fenugreek and 3.79 and 4.12 per cent over control after harvest of pearl millet. Seed treatment with PSB and PSB + *Rhizobium* also increased the available phosphorus in soil significantly during 1997-98 after harvest of fenugreek and during 1999 after harvest of pearl millet over control and *Rhizobium* inoculation.

It may thus be inferred that soil fertility measured in terms of available N, P and S improved after fenugreek crop over initial level but declined after pearl millet crop.

Table 1. Effect of phosphorus, sulphur and biofertilizers on yield and economics of fenugreek and their residual effect on pearl millet

Treatments	Seed yield of Fenugreek (q/ha)		Grain yield of Pearl millet (q/ha)		Net return (Rs/ha)				B : C ratio			
					Fenugreek		Pearl milet		Fenugreek		Pearl millet	
	1997-98	1998-99	1998	1999	1997-98	1998-99	1998	1999	1997-98	1998-99	1998	1999
Phosphorus (kg P_2O_5/ha)												
0	13.08	13.40	14.48	15.09	15284	15824	8369	8714	2.04	2.12	2.36	2.46
40	14.50	14.94	16.41	17.13	16895	17586	20132	11002	2.06	2.13	2.86	3.10
80	16.32	16.75	19.51	20.58	19265	19962	12765	13345	2.13	2.21	3.60	3.76
C.D. (P=0.05)	0.590	0.824	1.084	1.412	775.0	1403.3	617.2	917.6	NS	NS	0.24	0.24
Sulphur (kg S/ha)												
0	14.10	14.51	16.17	16.70	16478	17167	9919	10290	2.05	2.12	2.79	2.90
50	14.57	14.96	16.69	17.55	17001	17613	10344	10973	2.06	2.14	2.92	3.09
100	15.24	15.61	17.54	18.56	17964	18593	11003	11798	2.12	2.19	3.20	3.33
C.D. (P=0.05)	0.590	0.824	1.084	1.412	775.0	1403.3	617.2	917.6	NS	NS	0.24	0.24
Bio-fertilizers inoculation												
Control	14.38	14.76	16.55	17.30	16722	17364	10180	10785	2.03	2.11	2.87	3.04
Rhizobium	14.56	14.98	16.69	17.50	17023	17708	10336	10956	2.06	2.14	2.91	3.09
PSB	14.70	15.08	16.85	17.65	17254	17902	10513	11070	2.09	2.17	2.96	3.12
Rhizobium+PSB	14.91	15.30	17.11	17.96	17592	18191	10659	11269	2.12	2.20	3.00	3.17
C.D. (P=0.05)	0.336	0.303	NS	NS	287.3	484.3	NS	NS	0.03	0.06	NS	NS

Table 2. Effect of phosphorus, sulphur and bio fertilizers applied to fenugreek on soil fertility measured after harvest of fenugreek and pearl millet

Treatments	Nitrogen (kg/ha)				Phosphorus (kg P_2O_5/ha)				Sulphur (kg S/ha)			
	Fenugreek		Pearl millet		Fenugreek		Pearl millet		Fenugreek		Pearl millet	
	1997-98	1998-99	1998	1999	1997-98	1998-99	1998	1999	1997-98	1998-99	1998	1999
Phosphorus (kg P_2O_5/ha)												
0	122.81	120.70	116.09	111.83	24.88	24.07	22.56	22.06	13.92	13.34	12.87	12.51
40	124.53	120.85	116.20	112.02	31.65	30.88	29.43	28.95	13.98	13.39	12.90	12.53
80	123.35	121.27	116.64	112.63	36.60	35.83	34.72	34.01	15.03	14.42	13.85	13.55
C.D. (P=0.05)	NS	NS	NS	NS	1.111	2.523	2.569	1.179	NS	NS	NS	NS
Sulphur (kg S/ha)												
0	123.27	120.58	115.94	111.80	30.39	30.18	28.79	28.25	11.99	11.36	10.93	10.58
50	123.10	121.00	116.32	112.28	30.99	30.21	28.91	28.32	14.54	13.94	13.48	13.15
100	124.31	121.24	116.67	112.40	31.25	30.37	29.02	28.45	16.41	15.84	15.21	14.86
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	1.318	1.227	1.231	1.583
Bio-fertilizers inoculation												
Control	120.50	118.44	113.86	109.77	30.42	29.55	28.13	27.65	14.11	13.52	13.04	12.73
Rhizobium	124.69	122.62	118.11	113.99	30.50	29.64	28.22	27.77	14.22	13.60	13.14	12.77
PSB	121.77	119.63	114.70	110.58	31.51	30.82	29.74	28.92	14.44	13.84	13.43	13.04
Rhizobium+PSB	127.28	123.08	118.56	114.29	31.75	31.01	29.52	29.03	14.49	13.90	13.23	12.91
C.D. (P=0.05)	3.500	2.306	2.671	2.637	1.139	NS	NS	1.140	NS	NS	NS	NS

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STABILITY ANALYSIS FOR OIL YIELD AND QUALITY IN SOYBEAN (*GLYCINE MAX* (L.) MERRILL)

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ABSTRACT

The present study was undertaken to study the genotype × environment interaction affecting oil yield and quality parameters and to identify stable genotypes for these traits. A total of 30 genotypes were evaluated in six environments during Kharif, 1999. Significant environmental (linear) variances were observed for all the characters except for oleic acid (%). SL 432 was stable for oil content as well as linoleic acid, however, no genotype was found to be stable for oil content as well as linoleic acid, however, no genotype was found to be stable for oil content as well as linoleic acid, however, no genotype was found to be stable for oleic acid. For palmitic acid SL 517 and SL 466 were stable, whereas genotype SL 518 was stable for low linolenic acid. The variety SL 295 in addition to having highoil content also had low linolenic acid. Therefore, this variety could effectively be used in the future breeding programme for developing genotypes with better quality oil.

Key words : Soybean, stability, oil yield, fatty acids.

The soybean (*Glycine max* (L.) Merrill.) is an economically important legume crop because it is rich in protein and oil. Breeding efforts devoted to the genetic improvement of soybean oil quality have intensified over the past decade. The primary emphasis has been the genetic alteration of unsaturated fatty acid composition in the seed oil. Soybean genotypes with modified fatty acid composition in the seed oil are being considered for commercial production. Stability of performance across environments is considered essential for the release of soybean genotypes with improved oil quality which is determined by the fatty acid composition of the oil. The F.A. composition of soybean oil is influenced by the environment in which plants are grown. Planting dates have been shown to affect fatty acid composition (Hammond and Fehr, 1975 and Chu and Sheldon, 1979). Significant genotype × environment interactions have been measured for all the fatty acids in soybean oil Hawkings et al. (1983). It is important for the breeders and soil users to understand the effect of environment on the composition of soybean oil from genotypes with unique fatty acid content. Therefore, the present study was planned to study the effect of genotype × environment interaction (sowing dates and locations) on the fatty acid composition of different genotypes and to identify stable genotypes.

MATERIAL AND METHODS

Thirty diverse genotypes of soybean were sown in randomized block design with three replications. The material was sown at three locations with two dates of sowing at each location during kharif, 1990. Each genotype was planted in three rows of 3 meter length with row to row spacing of 45 cm. The recommended fertilizers and cultural practices were followed. The seed harvested from five randomly taken plants in each replication was used to analyze oil yield and quality traits, oil content and fatty acids. Oil content was estimated by the Nuclearn Magnetic Resonance technique (Alexander, 1967) while fatty acids were determined by GAs Liquid Chromatography. The data was analyzed statistically following Eberhart and Russell Model (1966);

RESULTS AND DISCUSSION

The analysis of variance for oil yield and quality characters in individual environments revealed that differences among the genotypes were highly significant for most of the traits in all the six environments. Highly significant variances due to genotypes tested against pooled error revealed the presence of genetic variability for all the quality parameters under investigation (Table 1). Variances due to environments were highly significant for all the fatty acids except for oleic acid when tested against pooled error. The component genotype environment interaction being highly significant indicated that the

Table 1. Pooled analysis of variance over environments for different characters

Source of variation	d.f.	Oil-content (%)	Fatty acid composition (%)			
			Palmitic acid	Oleic acid	Linoleic acid	Linolenic acid
Genotypes	29	13.57**	7.61**	60.09**	51.95**	3.38**
Env.	5	13.75**	0.61**	2.05	14.79**	5.75**
Geno × Eng.	145	1.48**	2.34**	14.47**	15.72**	1.66**
Error	348	1.05	0.23	2.98	4.90	0.41

* Significant at 5% level

** Significant at 1% level

genotypes interacted considerably to environmental conditions. Significant genotype × location and genotype × environment interactions have been reported for oil content by Nian Hai et al. (1997). They have advocated that G × E interactions should be considered in breeding for high oil soybean lines as it may lead to instability of genotypes and effect the ranking of the genotypes when they are grown in diverse environments. The pooled analysis of variance for stability of oil content and fatty acids (Eberhart and Russell Model, 1966) is given in table 2. The significant linear variance due to environment except for oleic acid. The linear variance due to GXE was highly significant for all the characters under study. The more pronounced linearity over non-linearity for oleic acid and palmitic acid indicated that variations among the genotypes could largely be explained by differences in regression value. This obviously revealed that the accurate prediction of the phenotypic performance of the genotypes can be deducted for these for these traits. Significant variance due to pooled deviations were observed for all the fatty acids. The negative values of regression coefficients in some genotypes for these characters might be due to relatively high linear regression on the environmental indices (Bains and Gupta, 1972). Eberhart and Russell (1966) in their studies have observed regression to be more important. Chowdhry and Paroda (1980) have advocated that linear regression (b) could simply be regarded as a measure of response of a particular genotype and deviation from regression should be regarded as a better measure of stability.

Table 2. Analysis of variance for stability of different characters (Eberhart and Russell model)

Source of variation	d.f.	Oil-content (%)	Fatty acid composition (%)			
			Palmitic acid	Oleic acid	Linoleic acid	Linolenic acid
Genotypes	29	4.52**	2.54**	20.03**	17.31**	1.13**
Env. + (G × E)	150	0.93**	0.77**	4.73**	5.56**	0.72**
Env. linear	1	68.76**	3.05**	10.26	73.93**	28.72**
G × E (Linear)	29	0.97**	1.77**	9.59**	12.8**	1.43**
Pooled deviations	120	0.36	0.51**	3.51**	3.22**	0.32**
Pooled error	348	0.35	0.08	0.99	1.63	0.14

* Significant at 5% level

** Significant at 1% level

The performance of genotypes over the environments revealed that oil content varied from 19.32 (JS-91-4) to 23.05 (SL 432) per cent (Table 3). The stability parameters revealed that SL 427 and SL 295 had high mean oil per cent (22.69 and 22.06, respectively), below average stability (b>1) and nonsignificants deviation from regression line, thus, these genotypes would perform better under favourable environments and their performance could be predicted. Genotypes SL 345, SL 428, PK 416 and SL 517 had high mean oil percent, above stability and non significant deviations thus making these genotypes suitable for poor environments with predictable performance. Genotype SL 432 having highest oil content, i.e. 23.05 per cent was found to be stable over the environments but its performance was unpredictable due to significant deviations from regression line, however, SL 427 was observed to be stable over the environments with predictable performance.

The mean performance of genotypes over the environments (Table 3) indicated a range of palmitic acid from 11.51 per cent (SL 443) to 13.64 per cent (SL 528). The palmitic acid content in soybean cultivars has been reported to be 11.0 per cent by Bubeck et al (1989). The oleic acid per cent ranged from 21.13 in PK 1241 to 27.84 in SL 427. Lu et al (1990) have reported oleic acid content to vary from 11 to 39 per cent in different germplasm lines of soybean. SL 328 (27.48%), SL 428 (26.53%), SL 423 (26.39%), PK 416 (26.27%) and SL 561 (25.91%) also had high eleic acid content. It was observed that increase in oleic acid was accompanied by decrease in linoleic and linolenic acids, which had also been reported by Alderks (1949). The genotype PK 1241 had high linoleic acid (55.31%) followed by SL 443 (54.56%) and PK 1197 (53.85%). The genotype SL 328 recorded lowest value (48.69%) for this fatty acid. The fatty acid composition of soybean oil largely determines it suitability for edible and industrial purposes. Linolenic acid is considered as an unstable component which is responsible for poor flavour and undesirable oil odour, particularly in oils that are heated during use (Mounts et al 1988).

Lu *et al.* (1990) in their studies have reported a range of 5-14 per cent for linolenic acid. Genotypes with reduced linolenic acid content have been developed which could improve acceptability of the oil for edible use (Takagi et al 1990). In the present studies linolenic acid content varied from 7.93 per cent in SL 518 to 9.91 per cent in SL 432. The genotypes with low linolenic acid were SL 427 (8.04%), PK 1197 (8.29%), SL 477 (8.36%) and SL 295 (8.36%).

A perusal of the stability parameters revealed that for palmitic acid genotypes SL 564, SL 428 and SL 433 had high mean (12.98, 12.81 and 12.60 per cent, respectively), below average stability and nonsignificants deviations from regression line thus making these genotypes suitable under favourable environments with predictable performance. PK 1197 had high mean (12.72%), negative regression coefficient and non significant deviation from regression line, which indicated that this genotype could perform well under poor environments. Genotypes SL 517 and SL

Table 3. Mean and phenotypic stability parameters for different characters

S. No.	Genotypes	Oil Content			Palmitic Acid			Oleic Acid			Linoleic Acid			Linolenic Acid		
		Mean	Bi±S.E.	S^2di	Mean	Bi±S.E.	S^2di	Mean	Bi±S.E.	S^2di	Mean	Bi±S.E.	S^2di	Mean	Bi±S.E.	S^2di
1.	SL427	22.69	1.10±0.29	1.56	11.77	-1.34±3.71	2.20**	27.84	-0.06±1.25	-0.46	49.40	3.49±1.17	1.78**	8.04	2.69±0.95	0.73**
2.	SL457	20.79	0.23±0.30	1.84	13.10	-0.77±3.34	1.76**	24.58	5.42±4.16	4.94**	49.87	4.18±1.54	4.21**	9.35	-0.26±0.43	0.04
3.	PK1023	20.86	1.81±0.19	-0.26	12.00	-0.78±1.02	-0.09	21.72	5.53±1.36	-0.36	53.72	2.62±0.54	-0.92	8.97	0.51±0.24	-0.08
4.	PK1197	21.13	1.52±0.22	-0.24	12.72	-2.010±.71	0.00	22.45	6.32±3.29	2.72**	53.85	3.44±1.05	1.12*	8.29	1.27±0.81	0.50**
5.	PK1241	21.36	1.43±0.17	-0.28	12.30	2.24±1.28	-0.19	21.13	6.43±1.19	-0.51	55.31	2.11±0.59	-0.76	8.85	0.70±0.68	0.30**
6.	SL443	21.07	0.60±0.24	-0.22	11.51	4.20±1.59	0.34	22.46	-1.74±3.45	3.08**	54.56	-0.34±0.98	0.73*	8.46	1.56±0.34	-0.03
7.	SL444	20.85	1.75±0.12	-0.32	12.26	0.81±3.04	1.45*	23.38	7.67±4.18	4.99**	52.28	2.80±2.12	9.52**	8.92	1.78±0.67	0.30**
8.	PK1169	20.49	0.55±0.20	-0.25	12.84	1.56±3.39	1.82**	22.21	7.40±3.85	4.09**	52.78	2.07±1.01	0.93*	9.73	-1.65±0.48	0.08**
9.	PK1180	21.28	1.54±0.42	0.06	11.73	1.08±1.26	-0.18	23.51	6.63±3.64	1.41	53.03	3.94±0.76	-0.18	8.66	1.65±0.67	0.29**
10.	PK1189	20.95	0.79±0.27	-0.18	11.81	0.13±1.40	0.24	25.43	-5.22±2.88	1.86*	51.55	-0.37±1.13	1.53**	8.44	1.76±0.25	-0.08
11.	SL466	21.23	1.36±0.31	-0.13	12.63	0.91±1.94	0.54	24.77	0.04±3.61	3.48**	51.18	3.10±1.13	1.54**	8.55	2.03±0.34	-0.03
12.	SL467	20.83	0.83±0.25	-0.20	11.95	0.50±1.95	0.55	24.15	4.75±3.34	2.84**	52.37	2.02±1.08	1.29*	8.74	1.68±0.39	0.01
13.	SL477	20.77	1.61±0.18	-0.27	12.14	-0.31±1.44	0.26	23.78	-0.00±1.43	-0.28	53.23	2.78±0.27	-1.44	8.36	0.35±0.19	0.01
14.	SL495	21.47	0.92±0.39	0.00	12.16	0.80±1.91	0.52	24.16	-7.19±3.21	2.54**	51.98	-0.79±0.76	-0.22	8.73	1.74±0.51	0.11
15.	SL518	21.04	0.71±0.32	-0.12	12.38	0.79±1.57	0.32	24.79	1.24±2.47	1.10	52.85	0.29±0.56	-0.85	7.93	-0.78±0.17	2.77**
16.	SL523	21.17	1.02±0.28	-0.17**	12.00	0.19±0.24	-0.07	24.69	6.57±5.80	10.52**	52.18	3.76±1.97	7.91**	8.57	1.73±0.65	0.26*
17.	JS-91-4	19.32	-0.01±0.70	0.78**	12.50	1.82±1.71	0.40	22.04	-1.17±4.15	4.92**	53.26	0.01±1.59	4.61**	9.27	0.07±0.25	-0.08
18.	SL528	20.57	1.66±0.57	0.41**	13.64	5.42±4.33	3.02**	23.25	-3.91±4.73	6.68**	51.40	-4.92±1.62	4.84**	8.78	0.80±0.31	-0.05
19.	SL561	20.73	1.53±0.17	-0.28	12.72	-1.64±3.31	1.73**	25.91	-6.81±3.46	3.13**	49.92	-0.58±2.17	9.98**	8.66	0.80±0.17	-0.11
20.	SL564	21.13	1.78±0.37	-0.03	12.98	3.98±2.50	0.95	25.64	-2.69±2.84	1.77**	49.66	-2.85±1.11	1.44*	8.81	1.28±0.50	0.1
21.	SL328	22.36	1.87±0.72	0.82**	12.07	1.19±1.52	0.30	27.48	-0.33±0.92	-0.70	48.69	-0.33±0.65	-0.59	8.94	1.46±0.50	0.1
22.	SL345	22.32	0.83±0.45	0.11*	11.64	1.67±2.66	1.09	25.06	-9.46±5.00	7.58*	51.75	-2.55±0.83	0.09	8.66	1.53±0.48	0.08
23.	SL414	22.72	0.75±0.62	0.53**	12.29	1.20±0.73	-0.01	22.78	0.33±1.16	-0.52	53.07	-0.28±0.62	-0.64	8.99	1.90±0.56	0.17*
24.	SL423	22.91	1.48±0.59	0.45**	11.99	-0.18±2.29	-0.79	26.39	-4.23±3.14	2.4**	49.66	0.04±0.77	-0.18	8.61	1.79±0.50	0.1
25.	SL428	22.97	-0.06±0.33	-0.11	12.81	1.59±3.23	1.65*	26.53	-3.93±2.14	0.58	49.70	-0.03±1.42	3.35**	8.58	0.61±0.25	-0.08
26.	SL432	32.05	1.02±0.45	0.11*	12.42	2.28±3.99	2.55**	21.79	7.55±1.77	0.09	53.22	1.19±0.43	-1.17	9.91	-1.09±0.46	0.06
27.	SL433	21.63	0.93±0.50	0.23*	12.60	2.69±2.89	1.30	22.76	10.10±5.02	7.65**	52.41	2.46±1.22	2.25**	9.23	-0.84±0.26	-0.08
18.	SL517	21.67	0.45±0.45	0.13*	13.39	0.99±2.30	0.79	21.34	-1.61±2.01	0.39	53.45	-1.67±0.44	-1.15	9.09	1.63±0.44	0.05
29.	PK416	21.59	0.69±0.26	-0.19	12.30	1.74±1.69	0.39	26.21	-2.46±0.60	-0.87	49.76	0.60±0.32	-1.38	8.70	1.93±0.39	0.01
30.	SL295	22.06	1.15±0.47	0.16*	12.23	1.17±0.89	0.05	23.73	5.68±2.02	0.41	52.12	3.78±0.82	0.02	8.36	1.43±0.36	-0.01
	Mean	21.43			12.32			24.07			51.94			8.77		
	S.E.	±0.34			±0.16			±0.57			±0.74			±0.22		
	Range	19.32-23.05			11.51-13.64			21.13-27.84			48.69-55.31			7.93-9.91		

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COMBINING ABILITY STUDIES IN LATE GROUP CAULIFLOWER

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ABSTRACT

Combining ability analysis helps in selecting the parents/lines best suited for making hybrids which are commercially more viable. Combining ability of nineteen (19) late and mid late group cauliflower lines was tested in line × tester mating system by involving late group varieties PBS-1 and PSBK -1 as testers. The lines Kathmandu Local, Pusa Synthetic and Snowball - 16 were god combiners for gross weight, marketable yield and curd size index. Amongst the testers PSBK-1 combined well for high gross weight.

Key words : Combining ability, late cauliflower.

Last decade, India witnessed a phenomenal increase both in area and production of different vegetables. The hilly terrian of Himachal Pradesh which provides an excellent opportunity for cultivation of off-season vegetables was the leader in getting the benefit out of this change. This happened primarily due to the introduction of high yielding and widely adaptive hybrids in different vegetables, tomato, cabbage, cauliflower and capsicum being the leaders. Cauliflower (Brassica oleracea var oleracea L) is the crop in which inspite of different maturity groups a number of hybrids have been successfully developed in early and mid groups in contrast to late group. This is primarily due to the reasons of i) unavailability of suitable good combining parents and ii) absence of any stable natural mean of easy cross pollination in late group which helps in making sufficient seed of the hybrids. Combining ability analysis viz. general combining ability of parents and specific combining ability of the hybrids provide information for selecting suitable parents for the development of hybrids and synthetics. Hence, the present study was conducted to ascertain the combining ability of different genotypes of mid late and late maturity group cauliflower in a line × tester system of mating for further exploitation.

MATERIALS AND METHODS

Nineteen different lines of mod late and late group were crossed with two well established commercial varieties PBS-1 and PSB K-1, using line × tester mating system during 1996 and 1997 at the experimental farm of the Dr. YS Parmar University of Horticulture and Forestry, Nauni - solan. The parents and hybrids were tested in a randomized block design keeping three replications and following recommended cultural practices for the crop. Observations on ten randomly selected plants from each replication excluding two border plants were recorded by harvesting the curd at marketable maturity stage. Combining ability analysis was carried out following the procedure of Kempthorne (1957).

RESULTS AND DISCUSSION

Highly significant variances (Table 1) were found for a GCA and SCA estimates of all the characters suggesting that both additive and non additive types of gene actions were important for the improvement of the crop which is in line to the findings of Lal et al. (1977), Sharma et al. (1983) and Sharma et al. (1988). The parents/lines like Kathmandu Local, Pusa Synthetic, Snowball-16 and Janavon for marketable yield, gross weight, curd size index, curd depth and curd solidity; Snowball-16 and Kathmandu Local alongwith KT-25 for high leaf number and leaf size index; Monopreco and EC 162587 for lower stalk length and Pusa Himjyoti, RSK-1301, BR-2 and EC 162587 for early maturity of the curds were rated as the good combiners (Table 2). Among testers PSB-1 was desirable combiner for gross weight per plant, and curd size index whereas PSBK-1 for early curd maturity, marketable yield per plant, lower stalk length, lower number of leaves and curd solidity.

The lines Kathmandu Locl, Snowball-16, Pusa Synthetic, Janavon, KT-9, KT-25 gave good specific combining ability rating (Table 3) with any of the tester involved for almost all the traits. For days to curd maturity crosses Pyramis × PSBK-1 (-1.87), RSK-1301 × PSBK-1 (-1.75) and Himanshu Snow × PSB-1 (-1.23) had high negative SCA effects in the favourable direction. The best cross combinations for gross weight were KJ-38 × PSBK-1 (226.04), Kathmandu Local × PSB-1 (157.59), Snowball-16 × PSB-1 (134.94) and KJ-47 × PSBK-1(104.59) while for marketable yield out of these KJ-47 × PSBK-1 could not match with others as far as specific combining ability is concerned. KT-9 × PSBK-1, Pusa Synthetic ×PSB-1 and Janavon S-3 × PSBK-1, were the other crosses with good SCA effects for marketable yield. Snowball-16×PSB-1, KT-6 × PSBK-1 and Kathmandu

Table 1. Analysis of variance for combining ability

Source	d.f.	Days to maturity	Gross weight	Marketable yield	Curd size index	Curd depth	Stalk length	No. of leaves	Leaf size index	Curd solidity
Replication	2	18.15	42832.84	3463.86	258.66	0.30	3.23	2.32	9240.70	5.29
Females	18	141.21	92779.85*	25975.26*	912.93*	1.05*	0.14*	12.02*	183429.9*	279.19*
Males	1	7.71	46201.26	1533.05	225.07	0.14	0.08	3.19*	331.50	53.88
Female×male	18	6.18	237198.6*	10244.02	779.38*	0.76*	0.33*	10.36*	37098.03*	107.37
Error	74	7.89	24310.32	5410.27	169.04	0.34	0.07	0.91	10029.38	99.44
σ^2g		2.16	3771.05	111.43	8.58	-0.005	0.005	0.25	1739.05	1.88
σ^2s		-0.57	7296.98	1611.25	18.68	0.14	0.004	0.76	9022.88	2.64
$\sigma^2g/20s$		-3.78	0.52	0.07	0.46	-0.04	1.25	0.33	0.19	0.71

* Significant at 5%.

Table 2. Estimate of general combining ability effects of lines for different characters

Lines	Days to maturity	Gross weight	Marketable yield	Curd size index	Curd depth	Stalk length	No. of leaves	Leaf size index	Curd solidity
KJ-38	4.72*	131.91*	34.56	24.95*	-0.19	0.14	0.34	186.55*	5.64
KJ-47	7.99*	30.36	-2.66	7.54	-0.35	-0.13	0.68*	33.47	3.68
KM-1	-0.37	-38.36	-22.79	6.97	-0.15	0.05	-0.85*	107.07*	-1.34
Snowball-16	3.88*	-2.38	75.46*	12.75*	0.65*	-0.10	2.02*	55.17	1.74
Pyramis	3.39*	-1.11	-39.24	-11.33*	-0.16	0.11	0.05	-52.03	-2.38
Monopreco	6.37*	-51.98	-34.49	0.89	-0.70*	-0.24*	0.44	54.58	3.21
Janavon	-2.19*	219.02*	65.48*	14.09*	-0.16	0.15	-0.83*	227.60*	9.05*
Holland Special	-3.96*	-113.13*	-72.82*	-11.51*	-0.69*	-0.14	0.95	-165.42*	-1.39
Himanshu Snow	1.57	16.51	-54.55*	-2.11	-0.22	0.02	-0.83*	-64.87*	-4.19
Pusa Himjyoti	-7.65*	-246.26*	10.58	-11.81*	-0.25	0.15*	-0.56	-272.69*	3.85
EC-162587	-5.47*	7.54	-50.50*	-1.33	0.33	-0.24*	-0.39	-153.68*	-8.61
RSK-1301	-7.23*	-72.46	-17.56	-7.18	0.12	0.11	-1.71*	-46.93	-0.87
BR-2	-5.76*	-89.44	-1.07	-10.68*	-0.12	-0.16	1.74*	-20.12	-1.63
SN-445	-1.19	76.39	32.56	-7.43	0.61*	-0.01	0.09	-86.65*	-2.57
KT-9	1.21	62.84	6.08	-4.32	-0.24	-0.19*	2.70*	-169.54*	2.66
KT-25	3.61*	106.49*	39.68	1.00	0.01	0.09	2.44*	212.95	4.22
Pusa Synthetic	6.52*	123.16*	90.72*	165.03*	0.41*	0.27*	-0.26	422.85*	5.47
Kathmandu Local	2.60*	110.04*	111.06*	9.44*	0.76*	0.05	1.05*	-50.23	5.49
Janvon S-3	-2.85*	-269.16*	-170.27*	-25.46*	0.34	0.03	-2.71*	-216.02*	-22.04*
Testers									
PBS-1	0.26	45.61*	-3.68	0.83	0.04	-0.05*	-0.30*	2.07	-0.69
PSBK-1	-0.26	-45.61*	3.68	-0.83	-0.04	0.05*	0.30*	-2.07	0.69
SE(i)	0.90	49.72	23.46	4.15	0.19	0.08	0.30	31.94	3.18
SE (j)	0.20	11.72	5.53	0.98	0.04	0.02	0.07	7.53	0.75

* Significant at 5% level.

Local × PSB-1 were the best combiners for curd size index. Snowball-16 × PSB-1 were the best combiners for curd size index. Snowball-16 × PSB-1, Pusa Himjyoti × PSB-1, Himanshu Snow × PSBK-1 and KT-25 × PSB-1 were the best combinations for curd depth. KT-1× PBS-1, Mimanshu Snow × PSB-1 and Kathmandu Local × PSBK-1 were the best combinations for short stalk length. All the above listed crosses were found good combinations for higher number of leaves and leaf size index. Cross combinations KJ-47 × PSB-1 Janavon × PSB-1 and KJ-38 × PSBK-1 were the best combinations for the curd solidity. Thus it was clear that lines Kathmaandu Local, Snowball-16, Pusa Synthetic, Janavon, KT-9 and KT-25 were the best specific combiners with one of the testers for almost all the characters. All these involved good × poor, poor general combiner parents. It may be due to complementary gene action and genetic diversity of the parents involved in the crossing programme. It Swarup et al. (1963) have also reported such type of results late group cauliflower.

In general the characters which exhibited high SCA efforts may not respond to selection and in such cases heterosis breeding may be profitable. Additive genetic variance can be exploited successfully in cauliflower as most of the characters exhibited significant high GCA effects.

Table 3. Estimate of specific combining ability effects of hybrids for different characters

Lines		Days to maturity	Gross weight	Marketable yield	Curd size index	Curd depth	Stalk length	No. of leaves	Leaf size index	Curd solidity
KJ-38	X PSB-1	0.58	-226.04*	-80.93*	-3.75	-0.28	0.01	-0.60*	62.65*	-6.53*
	X PBSK-1	-0.58	226.04*	80.93*	3.75	0.28	-0.01	-0.60*	-62.65*	6.53*
KJ-47	X PSB	-0.30	-104.59*	24.18	-2.96	-0.41	0.06	0.16	-49.90	7.63*
	X PBSK-1	0.30	104.59*	-24.18	2.96	0.41	-0.06	-0.16	49.90	-7.63*
KM-1	X PSB	-1.03	61.89	24.34	6.70	-0.09	0.10	0.60*	143.03*	3.67
	X PBSK-1	1.03	-61.89	-24.34	-6.70	0.09	-0.10	-0.60*	-143.03*	-3.67
Snowball-16	X PSB	0.80	134.94*	65.53*	9.24	0.74*	0.01	0.17	38.30	-0.38
	X PBSK-1	-0.80	-134.94*	-65.53*	-9.24	-0.74*	-0.01	-0.17	-38.30	0.38
Pyramis	X PSB	1.87*	7.97	-36.60	-4.18	-0.65*	0.09	-0.36	76.50*	2.28
	X PBSK-1	-1.87*	-7.97	36.60	4.18	0.65*	-0.09	0.36	-76.50*	-2.28
Monopreco	X PSB	0.69	-83.96	-4.98	5.53	-0.12	-0.02	-0.18	55.22	0.68
	X PBSK-1	-0.69	83.96	4.98	-5.53	0.12	0.02	0.18	-55.22	-0.68
Janavon	X PSB	1.00	-1.06	34.98	0.80	-0.29	-0.10	-0.19	-84.77*	7.22*
	X PBSK-1	-1.00	1.06	-34.98	-0.80	0.29	0.10	0.19	84.77*	-7.22*
Holland Special	X PSB	0.92	-37.81	-21.85	-5.77	-0.11	-0.03	-0.88*	88.95	-1.32
	X PBSK-1	-0.92	37.81	21.85	5.77	0.11	0.03	0.88*	-88.95*	1.32
Himanshu Snow	X PSB	-1.23	-38.31	-30.57	-1.53	-0.44*	-0.21*	0.48	-37.43	0.82
	X PBSK-1	1.23	38.31	30.57	1.53	0.44*	0.21*	-0.48	37.43	-0.82
Pusa Himjyoti	X PSB	-1.10	68.56	29.92	-1.80	-0.69*	-0.11	-0.15	-57.12	-4.42
	X PBSK-1	1.10	-68.56	-29.92	1.80	0.69*	0.11	0.15	57.12	4.42
EC-162583	X PSB	-0.77	56.12	-21.34	5.28	0.05	0.10	-0.70*	4.28	-2.34
	X PBSK-1	0.77	-56.12	21.34	-5.28	-0.05	-0.1	0.70*	-4.28	2.34
RSK-1301	X PSB	1.75	-0.38	-28.07	-2.03	0.17	-0.13	-1.81*	55.50	-5.03
	X PBSK-1	-1.75	0.38	28.07	2.03	-0.17	0.13	1.81*	-55.50	5.03
BR-2	X PSB	-0.94	51.94	-1.75	-4.72	0.11	0.15	-0.41	101.58*	-1.30
	X PBSK-1	0.94	-51.94	1.75	4.72	-0.11	-0.15	0.41	-101.58*	1.30
SN-445	X PSB	0.02	67.97	5.07	-6.17	-0.04	-0.02	-0.31	54.28	0.85
	X PBSK-1	-0.02	-67.97	-5.07	6.17	0.04	0.02	0.31	-54.28	-0.85
KT-9	X PSB	0.64	-56.54	-58.22*	-10.82*	-0.19	-0.25*	0.52	-96.07*	-4.49
	X PBSK-1	-0.64	56.54	58.22	10.82	0.19	0.25	-0.52	96.07*	4.49
KT-25	X PSB	-1.14	-18.36	26.75	0.70	0.39*	0.01	0.43	-165.52*	-1.24
	X PBSK-1	1.14	18.36	-26.75	-0.70	-0.39*	-0.01	-0.43	165.52*	1.24
Pusa Synthetic	X PSB	-0.23	-29.69	63.99*	3.45	0.16	0.05	0.71*	-12.38	5.24
	X PBSK-1	0.23	26.69	-63.99	-3.45	-0.16	-0.05	-0.71*	12.38	-5.24
K.mandu Local	X PSB	-1.20	157.59*	51.13	14.40*	0.16	0.17*	1.33*	24.03	4.06
	X PBSK-1	1.20	-157.59*	-51.13*	-14.40*	-0.16	-0.17*	-1.33*	-24.03	-4.06
Janvon S-3	X PSB	-0.33	-10.21	-41.57*	-2.37	0.12	0.12	0.91*	-23.25	-5.40
	X PBSK-1	0.33	10.21	41.57*	2.37	-0.12	-0.12	0.91*	23.25	5.40
SE($_{ij}$)		0.10	47.72	23.46	4.15	0.19	0.08	0.30	31.94	3.18
SE (S_i-S_j)		1.62	90.01	42.47	7.50	0.34	0.15	0.55	57.81	5.75
SE (S_{ij}-S_{kj})		0.52	29.20	13.47	2.43	0.11	0.05	0.17	18.76	1.87
SE (S_{ij}-S_{ik})		2.29	127.30	60.06	10.61	0.48	0.21	0.78	81.77	8.14

* Significant at 5% level.

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INFLUENCE OF TIME AND NUMBER OF SPRAYS ON POPULATION OF MUSTARD APHID AND SEED YIELD OF MUSTARD

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ABSTRACT

A field experiment was conducted with Varuna variety of mustard (*Brassica juncea* L.) to evaluate the different spray schedules against mustard aphid. *Lipaphis erysimi* Kalt during *rabi* season at Agricultural Research Station, Mandor (Jodhpur). Seventy five days old crop was considered as most vulnerable stage at which control measures may be initiated. Two sprays staring at 75 days old crop followed by another spray at 15 days interval gave 2305 kg/ha seed yield with 1:12.88 incremental cost benefit ratio and 6.18 per cent loss in seed yield was observed in comparison to 2457 kg/ha and 1250 kg/ha seed yield obtained in completely protected and unprotected plots, respectively. Therefore, 75 days old mustard crop was regarded as most vulnerable stage at which control be initiated when population reached the level of 31.10 to 34.10 aphids/10 cm of inflorescence of central shoot and exposure period to aphid injury was 30 days considering the appearance of aphid on the crop 45 days after sowing when population was estimated below 1 aphid/ 10 cm of inflorescence of central shoot.

Key words : Mustard, aphid, *Lipaphis erysimi*, spray schedules, days after sowing (DAS) and exposure period.

Area under cultivation of Indian mustard, *Brassica juncea* L. has increased several fold in arid region of Rajasthan. Its productivity has been estimated as 9-10 q/ha which is low in comparision to 18-20 q/ha at the research farm. A number of factors are responsible for low productivity of mustard, among which insect pests play a major role. The mustard aphid, *Lipaphis erysimi* Kalt. is the most limiting factor in the successful cultivation of mustard. Losses in seed yield has been estimated as 28.55- 63.83% in different dates of sowing (Joshi *et al.* 1998). Present field study was conducted to ascertain the time of initiation of spraying and number of sprays of recommended insecticide required to maximize the monetary benefit and to make the insect control programme eco-friendly.

MATERIALS AND METHODS

Field studies on evaluation of different spray schedules for management of mustard aphid on 'Varuna' variety of mustard during *rabi* season were conducted at Agricultural Research Station, Mandor (Jodhpur). The crop was sown in first week of November in 4m x 3m plots with 3 replications in randomised block design. Recommended agricultural practices and fertilizer doses were applied to raise the crop. The plant to plant and row to row spacing was kept 30 and 10 cm, respectively. Spraying with knapsack sprayer was initiated 45 days after sowing (DAS) using 600 liter water/ha when the aphid started appearing on the crop. Monocrotophos 36 WSC (1ml/l) was sprayed to observe various spray intervals (Table 1). The interval between two sprays was kept 15 days. The crop was harvested in the first week of March. Number of aphids on 5 randomly selected plants per plot from each replication were counted by removing aphids from 10 cm terminal portion of the central shoot of a plant with a camel hair brush on a white paper sheet. Weekly observations on aphid population beginning from 44th days till 104th days after sowing were recorded. Initial and cumulative mean number of aphids observed in different spray schedules are given in Table 1. Seed yield data at harvest were also recorded. The pooled data on aphid population and seed yield for two years were subjected to statistical analysis.

RESULTS AND DISCUSSION

The pooled data on mean number of aphid/10 cm inflorescence of central shoot, seed yield, per cent avoidable loss, net economic returns and incremental cost-benefit ratio are presented in Table 1. Maximum seed yield (2457 kg/ha) was obtained in completely protected (treatment number 5) plots (five sprays, 45, 60, 75, 90 and 105 DAS) which was at par with treatment number 4 (four sprays, 45, 60 75 and 90 DAS), number 9 (four sprays, 60 75 90 and 105 DAS), number 14 (three sprays, 60 75 90 DAS), number 8 (three sprays, 75 90 and 105 DAS) and number 11 (two sprays, 75 and 90 DAS), number 8 (three sprays, 75 90 and 105 DAS) and number 11 (two spray, 75 and 90 DAS). Among these, treatment number 11, where spring was initiated 75 days after sowing followed by another spraying 90 days after sowing, gave 2305 kg/ha seed yield with 1:12.88 cost benefit ratio and 6.18 per cent loss in seed yield was observed. This was considered as best treatment because initiation of spraying earlier (45 & 60 old crop) or later (90 or 105 days old crop) than 75 days old crop resulted lower productivity (1611 to 1972 kg/ha) and higher per cent loss in seed yield (17.21 to 34.43). Therefore, 75 days old crop was regarded as most vulnerable stage at which control measures be initiated when population reached the level of 31.10 to 34.10 aphids/10 cm of inflorescence of central shoot and exposure period to aphid injury was 30 days population was estimated below 1 aphid/10 cm of inflorescence of central shoot. Rise in number of aphids/10 cm of inflorescence of central shoot beyond 31.10 to 34.65 and increase in exposure period more than 30 days resulted higher loss in seed yield and lower productivity. Per cent loss in seed yield at a level of 81.25 to 91.80 aphids/10 cm of inflorescence of central shoot and exposure period 45 days was 19.73% and at a level of 216.25 aphids/10 cm of inflorescence of central shoot and exposure period 60 days was 34.17. Suri *et al.* (1998) recorded negligible loss in seed yield when crop was exposed to aphid feeding for 15 days and maximum when crop was exposed for 75 days (75.5%). Thakur *et al.* (2001) recorded minimum of 6.62 per cent loss at 7 days exposure period

Table 1. Efficacy of different spray schedules against aphid on mustard (pooled data of 2 years)

Treatments	Spray schedules (Days after sowing)	Exposure period (Days)	Mean number of aphid /10 cm		Mean seed yied (kg ha^{-1})	Net economic return (Rs./ha)	ICBR	Mean % loss in seed yield
			Before initiation of spray	104th Days after sowing				
1.	45	-	0.85(1.11)^{*a}	101.75(10.11)^{f}	1646^{f}	3580	09.42	33.00
2.	45,60,	-	01.20(1.25)^{a}	65.95(8.15)^{cde}	1868de	5420	07.13	23.97
3.	45,60,75	-	0.65(1.07)a	36.15(.05)$_{be}$	2034$_{bcd}$	6700	0.5.87	17.21
4.	45,60,75,90	-	0.80(1.14)^{a}	04.10(2.14)^{a}	2256^{ab}	8549	06.61	08.81
5.	45,60,75,90,105	0	0.35(0.91)^{a}	0.505(5.32)^{a}	2457^{a}	10170	05.35	-
6.	105	60	216.25(14.09)^{f}	216.25(14.09)^{f}	1611^{f}	3230	08.50	34.43
7.	90,105,	54	91.80(9.46)^{d}	07.20(2.69)^{a}	1972^{cd}	6460	08.50	19.73
8.	7575,90,105	30	34.10(5.41)	10.60(2.92)^{a}	2319^{ab}	9550	08.38	0.5.16
9.	60,75,90,105	15	03.25(1.83)^{ab}	05.40(2.19)^{a}	2360^{a}	9580	06.30	03.94
10.	90	-	81.25(8.97)^{cd}	0.3.25(1.83)^{a}	1889de	6010	15.81	23.11
11.	75,90	-	31.10(5.17)^{bc}	01.15(1.28)	2305^{ab}	9790	12.88	06.18
12.	60	-	03.00(1.80)^{ab}	70.90 (8.36)^{cde}	1847de	5590	14.71	24.82]
13.	6,75	-	03.30(1.86)^{ab}	80.10(8.95)^{de}	20.41^{bcd}	7150	09.40	16.93
14.	60,75,90	-	03.20(1.83)^{ab}	15.00(386)^{ab}	2235^{abc}	8710	07.64	09.03
15.	75	-	34.65(5.52)^{bc}	57.50(7.28)^{cd}	1763de	8710	07.64	09.03
16.	Control	75	241.00(15.40)^{e}	241.00(15.40)^{f}	1250^{g}	-	-	49.12
	C.D. (P=0.05)		3.87	2.62	309	-	-	-
	C.V.%		-	-	-	-	-	-

Figures followed by similar letters do not differ significnatly at P=0.05%

*Figures in parenthese are squre root value

Cost of spray of monocrotophos 36 WSC including labour charge Rs. 380/ha and cost of produce Rs. 10/kg (Year 2002 rate) with highest benefit cost ratio of 1:8.07, 33.63 per cent loss in seed yield at 42 days aphid exposure period and 42.72 per cent avoidable loss in completely exposed crop. Singh and Sachan (1974) observed minimum 6.35 per cent avoidable loss with 20 days aphid exposure period with highest cost benefit ratio (1:19:29). The results of present study suggested 6.18 per cent loss in seed yield with 1:12:88 cost benefit ratio at 30 days aphid feeding exposure period which rose to 49.1% at 75 days aphid feeding exposure period. Minimum loss in seed yield with higher aphid exposure period (30 days) than the above three studies (7 to days) may be due to slower multiplication rate if aphid in arid environment of western Rajasthan. Further studies on effect of different environmental factors on growth and development of aphid, may led to more refinement of control measures against aphid.

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AVAILABLE ZINC AND ITS RELATIONSHIP WITH SOIL ZINC FRACTIONS IN SOME ALLUVIAL SOILS

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ABSTRACT

Four extactants were tried viz. 0.05 *N* HCl + 0.025 *N* H_2SO_4, EDTA + $(NH4)_2CO_3$ (pH 8.6), DTPA (pH 7.3) and 2 *N* $MgCl_2$ to asses the available zinc status of alkaline soils from Haryana and Delhi States. The extracted amounts of zinc by various extractants were correlated with soil zinc fractions. The extracting power of different extractants was in the order of 0.05 *N* HCl + 0.025 *n* H_2SO_4 > EDTA + $(NH4)_2CO_3$> DTPA (pH 7.3) > 2 *N* $MgCl_2$. Simple correlation revealed that DTPA had a better correlation with occluded zinc by sesquioxides (r=0.839**) and organically bound zinc (r=0.526*).

Key words : Soil test, zinc. available, fraction, extractants and alluvial soil.

Nearly 50% of soil samples analyzed so far have measured deficient in available zinc (Katyal and Rattan, 1990) and spectacular responses to zinc application have been reported in light textured and low in organic matter soils. Selection of promising extractant assumes great importance for rational use of Zn fertilizers in alluvial soils, as meager information exists. A number of soil testing procedures involving various chemicals such as dilute acids, chelating and complexing agents and neutral salts have been employed with varying degree of success for determination of available Zn. Therefore, the present study was undertaken to study the soil tests for available Zn and their relationship with various soil Zn fractions in alkaline soils.

MATERIALS AND METHODS

Ten surface (0-0.15 m) soil samples, differing widely in their Zn supplying power were collected from different location, viz. Sirmitla, Sonha district Gurgaon in Haryana and Mehrauli, Indraprasth and IARI Farm, New Delhi. The processed soil samples (<2 mm) were analyzed for mechanical composition, pH, EC, organic carbon, CEC and free $CaCO_3$ following the standard methods. The soils were analyzed for different Zn fractions viz. water soluble plus exchangeable (Zn-CA), specifically adsorbed on clay (Zn - AAC), organically bound (Zn-PYR), occluded by sesquioxides (Zn-OX) and residual Zn (Zn-RES) by the procedure of Mc Laren and Crawford

(1973) initially proposed for Cu fractionation, as modified by Asami *et al.* (1990). Residual Zn fraction was determined by difference, by subtracting all other fractions from the total Zn in the soil. Available Zn in soils was estimated by four different extractant like 0.05 *N* HCl + 0.025 *N* H_2SO_4 (1:4 soil-solution) time of shaking 15 minutes (Wear and Evens, 1968), 1*M* $(NH_4)_2CO_3$ + 0.01 *M* EDTA pH 8.6 (1:2 soil-solution) time of shaking 120 minutes, (Lindsay and Novel, 1978) and 2*N* 7.3 (1:2 soil-solution) time of shaking 25 minutes (Steward and Berger, 1965). Zn content in the centrifugates was determined by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

All soils were non-calcareous, non-saline and alkaline in reaction. Soils vary in texture from loamy sand to sandy clay loam with clay content ranging from 7.0 to 23.0% and low in organic carbon (0.20-0.51%). The important characteristics of the alkaline soils are presented in Table 1.

Soil Zinc Fractions

The data on different fractions of Zn and total Zn in all soils are presented in Table 2. Zinc content in water soluble plus exchangeable pools (Zn-CA) was virtually nonexistent in all the soils. Similar have been the observations of Deb *et al.* (1984) for alluvial soils. Zn fractions adsorbed on clay (Zn-AAC) occurred in larger proportions and constituted 6.21 to 13.59% of the total Zn in soils. It was the most dominant fraction only after residual Zn. Specific adsorption of Zn has been cited as a principal mechanism of Zn fixation under alkaline conditions. The organically bound zinc (Zn-PYR) was lower than the occluded Zn. Lower content of Zn-PYR (2.4-6.8 mg/kg) is the outcome of the low organic carbon status of the soils. Zn fraction occluded by sesquioxides (Zn-OX) ranged from 2.0 to 4.6 mg/kg and constituted 2.8 to 7.2% of total Zn content in soils. This is the fraction mainly bond to the amorphous sesquioxides. Zn-OX fraction in different soils is low as compared to Zn-PYR or Zn-ACC. Lower

Table 1. Some important physico-chemical properties of soils

Soil characteristics	Value
pH	7.4 - 9.0
EC (d S/m)	0.30 - 0.80
CaCO3 (%)	0.0 - 4.5
Sand (%)	62.0 - 85.0
Silt (%)	8.0 - 15.0
Clay (%)	7.0 - 23.0
Texture	Loamy sand-sandy clay loam
CEC (c mol (p+)/kg)	8.69 - 17.04
Organic carbon (%)	0.20 - 0.51
DTPA - Zn (mg/kg)	0.44 - 1.75

Table 2. Different fractions of soil Zn (mg/kg)

Fraction	Range	Mean	% of total Zn
Zn – CA	ND*	–	–
Zn – ACC	3.2 – 10.6	5.6	5.2 – 13.6
Zn – PYR	2.4 – 6.8	4.7	3.0 – 12.2
Zn – OX	2.0 – 4.6	2.9	2.8 – 7.2
Zn – RES	34.2 – 77.0	52.1	60.0 – 84.0
Zn – Total	46.0 – 92.0	65.4	100

ND* = Not detectable

magnitude of zinc content in sesquioxide fraction indicates the lower reactivity of sesquioxides under alkaline condition. The residual zinc (Zn-RES) was the most dominant fraction, constituting 73 to 84% of total Zn in soils. It showed that the majority of total zinc was held with in the silicate mineral structure.

Available zinc

Available Zn in soils as estimated by different extractant is presented in Table 3. The ranges of available Zn extracted by different extractant was found to be 1.04 to 3.76 mg/kg (0.05 *N* HCl + 0.025 *N* H_2SO_4), 0.70 to 2.60 mg/kg [$(NH_4)_2CO_3$+EDTA], 0.44 to 1.76 mg/kg (DTPA) and 0.15 to 0.50 mg/kg(2 *N* $MgCl_2$). HCl + H_2SO_4 extracted maximum amount of available Zn with a mean of 2.08 mg/kg. The higher solubility in acids may be due to solubility of many acid soluble compounds in the soil. The acids destroy the occluded Zn that are normally inaccessible to plants (Trierweiler and Lindsay, 1968). It showed that the acid extractant removed some Zn from insoluble metal oxides and secondary minerals also. The lowest quantity was extracted by 2 *N* $MgCl_2$ (0.15-0.50 mg/kg). This may be due to minimum and very slow rate of reaction of neutral salts with soil (Vasudeva and Narayana, 2001). Poor extractability of $MgCl_2$ is a result of irreversible bonding of Zn (Deb et al.. 1984). Non-detection of Zn in water soluble plus exchangeable pools (Zn - CA) as extracted with 0.05 *M* $CaCl_2$ supports the above contention; measurable values of Zn in $MgCl_2$ extracts, although it also mines Zn from the same pools, are due to the better replacing power of Mg at higher concentration in displacing Zn, as both Zn and Mg have comparable ionic radii (Stewart and Berger, 1965). Available Zn as extracted by EDTA + $(NH_4)_2CO_3$ and DTPA in different soils varied from 0.7 to 2.60 and 0.44 to 1.75 mg/kg, respectively. Both the extractant have extracted Zn from water soluble, exchangeable, adsorbed, complexed and chelated pools but higher value of Zn extracted by EDTA indicated its higher extracting power. Lindsay and Norvell (1978) reported that DTPA offered the most favorable combination of stability constant for simultaneous complexing of micronutrient cations. Haddad and Evens (1993) also found DTPA method as most suitable to predict bio-available Zn in calcareous soils.

Table 3. Available zinc (mg/kg) as extracted by different extractants

Soil location	Soil Classification	0.05 *N* HCl + 0.025 *N* H_2SO_4	DTPA pH (7.3)	2N $MgCl_2$	EDTA + $(NH_4)_2CO_3$
Delhi (Mehrauli)	Udic Ustochrepts	3.76	1.76	0.35	2.60
Delhi (Mehrauli)	Udic Ustochrepts	3.52	1.62	0.35	2.44
Sirmitla (Gurgaon)	Typic Ustochrepts	1.68	0.78	0.25	1.10
Sirmitla (Gurgaon)	Typic Ustochrepts	1.44	0.52	0.20	0.78
Delhi (Indraprastha)	Typic Ustochrepts	1.52	0.72	0.30	1.42
IARI Farm-1	Typic Ustochrepts	1.60	0.88	0.45	1.58
IARI Farm-2	Typic Ustochrepts	3.20	1.50	0.50	2.22
IARI Farm-2	Typic Ustochrepts	3.20	1.50	0.50	2.22
IARI Farm-3	Typic Ustochrepts	1.48	0.96	0.35	1.46
Sohna (Gurgaon)	Typic Ustifluvent	1.04	0.44	0.15	0.70
Mean		2.08	1.00	0.32	1.59
Range		1.04–3.76	0.44–1.75	0.15–0.50	0.70–2.60

The Zn extracting power of different extractant was in the following order or 0.05 *N* HCl + 0.025 *N* H_2SO_4 > 0.01 *M* EDTA + $(NH_4)_2CO_3$>DTPA pH 7.3>2 *N* $MgCl_2$.

Correlations

Simple correlation data presented in Table 4, revealed that DTPA (pH 7.3) had a significant correlation with Zn - PYR (r=0.526*), Zn - OX (r=0.839**). The acid extractant 0.05 *N* HCl+0.05*N* H_2SO_4 significantly and positively correlated with Zn-PYR (r=0.517*) and Zn - OX (r=0.812**). Another chelating agent EDTA+$(NH_4)_2CO_3$ was correlated with Zn-PYR (r=0.463*), Zn-OX (r=0.824**) and total zinc (r=0.499*). The neutral salt $MgCl_2$ showed positive and significant correlation with Zn-PYR(r=0.530*), and Zn-OX (r=0.721**). It was observed from the correlation data that all the four extractant had positively and

Table 4. Correlation coefficient between various Zn fractions and available Zn extracted by different extractants

Extractants	Fractions of soil Zn				
	Zn–AAC	Zn-PYR	Zn-OX	Zn-RES	Zn-Total
0.05 *N* HCl+0.025 *N* H2SO4	0.006	0.517*	0.812**	0.244	0.318
EDTA+(NH4)2 CO3	0.171	0.463*	0.824**	0.362	0.449
DTPA (pH 7.3)	0.062	0.526*	0.839**	0.306	0.387
2 *N* MgCl2	0.117	0.530*	0.721**	0.020	0.132

* Significant at 5% level ** Significant at 1% level

significantly correlated with organically bound zinc and occluded zinc fractions. From the above results it is evident that organically bound and occluded zinc are the principal forms contributing to the pools of available zinc in these soils. Multiple regression equations were computed relating available Zn extracted by different extractant and various zinc fractions. These equations are as follows :

$Y_1 = 0.065 + 0.088X3$; $R_2 = 0.521$

$Y_1 = -0.374 + 0.067\ X_1 + 0.150X_2 - 0.094X_3 - 0.002X_4$; $R_2 = 0.857$

$Y_2 = -0.356 + 0.467\ X_3$; $R_2 = 0.705$

$Y_2 = -0.617 + 0.047\ X_1 + 0.247\ X_2 + 0.125\ X_3 + 0.015\ X_4$; $R_2 = 0.721$

$Y_3 = -0.249 + 0.626\ X_3$; $R_2 = 0.679$

$Y_3 = -2.504 + 0.140\ X_1 + 0.460\ X_2 + 0.021\ X_3 + 0.020\ X_4$; $R_2 = 0.724$

$Y_4 = -0.680 + 0.939\ X_3$; $R_2 = 0.660$

$Y_4 = -2.572 + 0.014\ X_1 + 0.301\ X_2 + 0.515\ X_3 + 0.030\ X_4$; $R_2 = 0.675$

Where

Y1 = 2*N* $MgCl_2$-Zn, Y_2 = DTPA - Zn, Y_3 = EDTA+$(NH_4)_2CO_3$-Zn, Y_4 = 0.025 *N* HCl + 0.05 *N* H_2SO_4-Zn and X_1, X_2, X_3 and X_4 are adsorbed, organically bound, occluded by sesquioxides and residual zinc fractions.

Multiple regression equations show that contribution of different zinc fractions to 2*N* $MgCl_2$ extractable Zn is 85.7% and that of DTPA and EDTA+$(NH_4)_2CO_3$ are 72.1 and 72.4%, $MgCl_2$ extracts Zn from water soluble and exchangeable pools only whereas chelating agents DTPA and EDTA extract Zn from water soluble, exchageable, adsorbed, complexed and chelated pools.

Thus it is.possible to use DTPA or EDTA as an extractant in alkaline soils. Although all forms of Zn in the soil are known to supply the nutrient to soil solution, their relative contribution to the labile pool from which plant absorb the nutrient depends mainly on the solubility of the several zinc compounds as influenced by the relative characteristics of the soil. Thus we can assess the available Zn status of soils by knowing the contribution of different zinc fractions to available zinc. With all the facts discussed above it could be concluded that specifically adsorbed, organically bound and sesquuioxide occluded fractions of soil Zn are important and sensitive parameters in studying the availability of the nutrient in alkaline soils. Availability of this nutrient can been hanced by developing agro-technologies, which facilitate the accumulation of the added Zn in these fractions.

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EFFECT OF INTEGRATED NITROGEN NOURISHMENT AND GROWTH REGULATORS ON YIELD ATTRIBUTES AND GRAIN YIELD OF HYBRID RICE

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ABSTRACT

Field experiments were conducted during *kharif* seasons of 2001 and 2002 at the instructional farm of Indira Gandhi Agricultural University, Raipur, Chhatisgarh, to study the effect of integrated nitrogen nourishment and growth regulators on yield attributes and grain yield of hybrid rice. Results indicated that yield attributes viz., number of effective tillers hill^{-1}, panicle weight, number of spikelets, fertile spikelets panicle^{-1} and sterility percentage were appreciably higher under supply of N through integrated approach of 75% recommended N blended with cow dung urine or cow dung. Integrated approach of N being at par with that of application of 100% recommended N through chemical fertilizer resulted higher yield of hybrid rice and the maximum (85.2 q/ha) was realized with application of 75% recommended N blended with cow dung urine. Among the growth regulators, application of cycocel @ 1000 ppm proved significantly superior and resulted 6.6, 3.0 and 4.4% higher yield over control, brassinolide and tricontanol, respectively.

Key words : Hybrid rice, integrated nitrogen management, growth regulators, yield attributes, yield, hybrid rice.

The important reasons for low productivity of rice in India are poor soil fertility, imbalance and indiscriminate use of inorganic fertilizers and poor soil management practices. Among major plant nutrients, nitrogen management plays pivotal role to realize the higher yield. Hybrids of any crop as a rule needs more nutrient than a variety because of its higher yield. Chemical fertilizers are not only costly but are pollutant too. This calls to partially supplement and substitute the inorganic fertilizer. Integrated nitrogen management involving organic and inorganic sources of nutrition has a great scope to increase the productivity by proper blending. This not only sustains the soil fertility and productivity but also keeps the environment intact with reduced cost increment (Swaminathan, 1987). The information on integrated nitrogen nourishment and that too on hybrid rice in Chhatisgarh region which is known as "Rice Bowl" of the country is lacking. The role of crop growth regulator in agriculture is numerous and valuable.

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Substantial increase in the grain yield of cereals have been reported by Humpheris, 1968) & Singh and Singh (1996). Since hybrid rice is a new introduction in our country and its response to integrated nitrogen nourishment along with growth regulator is lacking. Hence the present study was undertaken to find out the effect of integrated nitrogen management and growth regulator on hybrid rice.

MATERIALS AND METHODS

Field experiments were conducted during *kharif* seasons of 2001 and 2002 under irrigated conditions at the instructional farm of Indira Gandhi Agricultural University, Raipur, Chhatisgarh. The experiment was laid out in a split plot design, assigning 9 nitrogen nourishment (N_0 – control, N_1 – 100% recommended (rec.) N, N_2 – 75% rec. N, N_3 – 75% rec. N + 25% N (FYM), N_4 – 75% rec. N + 25% poultry manure (PM), N_5 – 75% rec. N + 25% N (wheat straw WS), N_6 – 75% rec. N blended with cow dung urine (CDU), N_7 – 75% rec. N blended with cow dung (CD), N_8 – 75% rec. N + BGA (10 kg ha^{-1}) in main plots and 4 growth regulators viz., G_0 – Control, G_1 – Cycocel @ 1000 ppm, G_2 – Brassinolide @ 200 ppm, G_3 – Tricontanol @ 5 ppm in sub-plots with three replications. Recommended dose of N i.e., 150 kg N ha^{-1} was applied in four equal splits i.e., basal, tillering, panicle initiation and at flowering stage of the crop. The organic sources as per requirement of the treatment were applied and incorporated in the field. Growth regulators i.e., Cycocel @ 1000 ppm, Brassinolide @ 200 ppm and Tricontanol @ 5 ppm, were applied through knapsack hand sprayer at panicle initiation stage of the crop. All other agronomic management practices as per recommendation of the hybrid rice crop were followed.

RESULTS AND DISCUSSION

Application of 100% rec. N through chemical fertilizer or supply of N through integrated approach resulted appreciable improvement in the yield attributed of hybrid rice viz., number of effective tillers $hill^{-1}$, weight of panicle, number of spikelets, number of fertile spikelets $panicle^{-1}$ and reduced sterility percentage. However, the improvement was more conspicuous under application of 75% rec. N blended with CDU or CD (Table 1). The better performance in yield attributes under 75% rec. N blended with CDU or CD could be due to mineralization of organic sources and availability of released plant nutrients at later crop growth stages which might have resulted superior values of yield attributes. On the other hand, poor crop growth and development under control condition favoured to produce poor yield attributes.

Application of 75% rec. N blended with CDU, closely followed by CD blending registered the highest (85.2 q ha^{-1}) yield (Table 2). Superior performance of 75% N blended with CDU could be due to better growth favouring higher nutrient uptake and photosynthesis which resulted increased yield attributes and ultimately the yield. Similar views have been expressed by Upadhyay *et al.* (2000), Mishra and Prasad (2000) and Kumar *et al.* 2001).

Amongst growth regulator, cycocel

Table 1. Effect of integrated nitrogen nourishment and growth regulators on yield attributing characters of hybrid rice

Treatments	No. of effective tillers hill^{-1}		Panicle length (cm)		Panicle weight (g)		No. of spikelets panicle^{-1}		No. of fertile spikelets panicle^{-1}		Sterility percentage		1000-grain weight (g)	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Integrated N nourishment														
N_0 – No nitrogen	4.71	5.64	24.05	24.17	3.23	3.30	157.78	163.72	102.92	107.33	34.93	34.61	22.57	22.36
N_1 – 100% rec. N	13.15	13.26	28.50	28.59	4.75	4.82	205.62	215.19	135.12	141.07	34.38	34.53	23.48	23.54
N_2 – 75% rec. N	10.03	10.13	24.93	25.00	4.05	4.11	180.01	186.62	123.40	131.18	31.55	29.76	23.00	23.04
N_3 – 75% rec. N + 25% N (FYM)	12.80	12.92	26.41	26.53	4.61	4.69	196.74	209.17	141.90	149.86	27.96	28.42	23.33	23.39
N_4 – 75% rec. N + 25% N (PM)	12.69	12.87	25.59	25.70	4.56	4.64	187.82	197.88	132.87	140.38	29.35	29.12	23.28	23.36
N_5 – 75% rec. N + 25% N (WS)	12.97	13.13	27.25	27.37	4.73	4.81	200.52	214.47	145.21	153.04	27.67	28.70	24.47	24.53
N_6 – 75% rec. N blended with CDU	13.98	14.15	28.31	27.67	4.92	4.98	216.88	227.85	164.37	175.50	24.31	23.02	23.41	23.46
N_7 – 75% rec. N blended with CD	13.86	14.01	27.45	27.55	4.81	4.87	210.25	221.79	156.73	168.03	25.56	24.32	24.42	24.49
N_8 – 75% rec. N + BGA (10 kg ha^{-1})	12.50	12.63	25.21	25.29	4.12	4.20	184.72	193.34	129.66	136.40	29.88	29.46	23.11	23.20
C.D. (P=0.05)	1.22	1.31	2.35	2.47	0.39	0.43	21.04	18.78	7.65	8.23	2.12	2.32	1.58	1.52
Growth regulators														
G_0 – Control	11.56	11.79	25.71	25.80	4.38	4.45	176.28	185.85	119.93	128.32	32.18	31.15	23.17	23.23
G_1 – Cycocel @ 1000 ppm	12.09	12.30	27.22	27.33	4.59	4.67	206.29	217.94	149.61	157.49	27.66	27.90	23.75	23.70
G_2 – Brassinolide @ 200 ppm	11.93	12.15	26.47	26.57	4.49	4.57	197.96	207.75	141.44	148.78	28.78	28.66	23.47	23.53
G_3 – Tricontanol @ 5 ppm	11.83	12.07	26.23	26.02	4.44	4.52	192.94	201.80	136.66	144.42	29.41	28.71	23.42	23.48
C.D. (P=0.05)	0.08	0.09	0.13	0.17	0.04	0.03	2.21	2.53	1.75	1.83	0.53	0.61	0.45	0.41

Table 2. Grain and straw yields of hybrid rice as influenced by integrated nitrogen nourishment and growth regulators

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
	2001	2002	Pooled	2001	2002	Pooled
Integrated N nourishment						
N_0 – No nitrogen	32.41	33.31	32.86	52.23	54.48	53.35
N_1 – 100% rec. N	81.55	83.02	82.28	118.14	120.26	119.20
N_2 – 75% rec. N	66.62	67.45	67.04	103.36	104.52	103.94
N_3 – 75% rec. N + 25% N (FYM)	80.46	81.99	81.22	116.83	117.72	117.28
N_4 – 75% rec. N + 25% N (PM)	79.73	81.28	80.50	115.57	116.62	116.10
N_5 – 75% rec. N + 25% N (WS)	81.23	82.23	81.73	116.55	117.15	116.85
N_6 – 75% rec. N blended with CDU	84.62	85.86	85.24	115.70	115.87	115.78
N_7 – 75% rec. N blended with CD	83.91	84.52	84.21	111.23	112.50	111.86
N_8 – 75% rec. N + BGA (10 kg ha^{-1})	70.28	71.54	70.91	110.58	109.87	110.23
C.D. (P=0.05)	4.53	4.77	4.68	7.52	7.91	7.81
Growth regulators						
G_0 – Control	71.19	72.47	71.83	105.61	107.08	106.35
G_1 – Cycocel @ 1000 ppm	75.88	77.20	76.54	107.75	108.14	107.95
G_2 – Brassinolide @ 200 ppm	73.78	74.78	74.28	107.04	107.62	107.33
G_3 – Tricontanol @ 5 ppm	72.84	73.85	73.34	106.34	107.27	106.81
C.D. (P=0.05)	1.57	1.32	1.42	NS	NS	NS

proved significantly superior and registered the higher values of yield attributes of rice (Table 1). These increased parameters recorded with cycocel further resulted in achieving higher grain yield over rest of the growth regulators. The mean increase in grain yield of hybrid rice due to cycocel application was 6.6, 3.0 and 4.4% higher over control, brassinolide and tricontanol, respectively. The higher grain yield recorded with cycocel application may be due to greater source and sink potential and greater translocation of photosynthate towards the sink. The other probable reason for the increased grain field under cycocel treatment would be its capability in efficiently channelising the assimilates towards the grain. Samant and Sahu (1990) Singh and Singh (1996) also reported the similar views on the role of cycocel application.

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CHARACTER ASSOCIATION AND REGRESSION ANALYSIS IN CHICKPEA (*CICER ARIETINUM)*

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Selection for yield component is an efficient way of yield improvement in any crop. The present study undertaken to obtain information on correlational and direct and indirect effects of yield components on seed yield of chickpea *(Cicer arietinum* L.)

The experimental materials for the study comprised of 10 growth regulators (control, cephalexin @ 25, 50 and 75 mg/l, cystokinin @ 1.7, 3.4 and 5.1 ml/ha and cycocel @ 5000, 1000 and 1500 mg ma^{-1}). Genotype JG 74 was grown during rabi, 199-2000 in RBD with three replications at Instruction Farm, Indira Gandi Agricultural University, Raipur. Each treatment was sown in a 16-row of 4.4m in length with 30 cm distance between rows. The plant to plant distance was kept 5 cm. recommended package of practice for chickpea was adopted to raise a good crop. Observations of five andomly selected plants from each plot were reported on plant height (cm), dry weight noddies dry matter accumulation, GGR, RGR, LAL, total number of flower, number of pods, total chlorophyll content, seeds/pod, 100 seed weight, harvest index, nutrient content, LI and seed yield (q/ha). Correlation and path coefficient among all traits were estimated according to the method given by Dewey and Lu (1959). Multiple regression equations were also worked out.

The dependence of seed yield on various growth and yield parameter and well as interdependence among growth yield parameter wad evident from the positive and significant correlation (Table 1). The correlation coefficient of seed yield with total number of flower, number of pods (at harvest) and dry matter of pods (at harvest) were found significant at 5% probability level and pod growth rate (80-90 DAS) was found significant at 1% probability level.

Results of path analysis (Table 2) revealed that harvest index had high positive direct effect on seed yield followed by dry matter accumulation (90 DAS), 100-seed weight total number of flower. Crop growth rate (60-90 DAS), K-content of seed and light interception (80 DAS) showed positive correlation with seed yield but is direct was negative, while indirect contribution of harvest index was strongest contributory component for establishing positive correlation between GGR (60-90 DAS) and light interception (80 DAS) with seed yield. Total number of flower existed high positive indirect effect harvest index, 100 seed weight and dry matter accumulation (90 DAS) and negative indirect effect through crop growth rate (60-90 DAS), K-content of seed and light interception (80 DAS) on seed yield.

All the seven growth and yield attributing characters viz., dry matter accumula-

Table 1. Correlation matrix among growth, yield component and seed yield of chickpea

Characters	Nodule dry weight	Dry matter accumulation	Crop growth rate	Leaf area index	Total number of flowers	Number of pods	Total chlorophyll content	Seeds /pod	100-seed weight	Hrvest index	N content of seed	P content of seed	K content of seed	Light inter ception	Seed yield
Plant height	0.642*	0.606	0.341	0.722*	0.086	-0.155	0.427	0.246	0.036	-0.576	0.139	0.218	0.045	0.067	-0.048
Nodules dry weight		0.736	0.434	-0.798**	0.392	0.060	0.477	0.192	-0.113	-0.520	0.473	0.526	0.326	-0.189	0.040
Dry matter accumulation			0.790**	0.752*	0.433	0.187	0.592	0.268	-0.127	-0.450	0.668*	0.605	0.42	0.222	0.264
Crop growth rate				0.483	0.423	0.224	0.417	0.129	-0.089	-0.295	0.640*	0.496	0.354	0.079	0.239
Leaf area index					0.108	0.126	-0.334	-0.176	0.175	0.480	-0.151	-0.289	-0.115	-0.175	0.046
Total number of flowers						-0.120	0.664*	0.148	-0.088	-0.658*	0.427	0.443	0.296	0.009	-0.057
Number of pods							0.547	0.488	0.010	0.330	0.648*	0.546	0.305	0.115	0.602*
Total chlorophyll content								0.602	0.041	0.659*	0.55	0.471	0.301	0.121	0.761*
Seeds/pod									0.103	-0.072	0.723*	0.649*	0.536	0.071	0.443
100-seed weight										0.274	0.471	0.395	0.259	0.173	0.544
Harvest index											0.009	0.074	-0.088	-0.011	0.266
N content of seed												0.011	-0.035	0.150	0.606
P content of seed													0.829*	0.089	0.426
K content seed														-0.107	0.339
Light interception															0.186

*Significant at 5% level **significant 1% level.

Table 2. Direct and indirect effect as partitioned by path analysis

Characters	Dry matter accumulation	Crop growth rate (60-90 DAS)	Total number of flowers	100 seed weight	Harvest index	K content of seed	Light interaction (80 DAS)	Correaltion with seed yield
Dry matter accumulation (90 DAS)	0.7341	-0.1339	0.0324	-0.0614	-0.4336	0.1048	-0.0362	0.2646
Crop growth rate (60-90 DAS)	0.7924	-0.1639	0.0314	-0.0278	-0.2841	-0.0901	-0.0130	0.2398
Total number of flowers	0.4338	-0.0717	0.0749	0.0031	0.3181	-0.0775	-0.0187	0.6620
100 seed weight	-0.1977	0.0151	0.008	0.3111	0.1132	0.0224	0.0019	0.2668
Harvest index	-0.4516	0.0500	0.0248	0.0366	0.9621	0.0089	-0.0246	0.6062
K content of seed	0.4134	-0.0600	0.229	-0.0274	-0.0338	-0.2451	-0.0064	0.0545
Light interception (80 DAS)	0.2225	-0.0135	0.0086	-0.0036	0.1451	-0.0101	-0.1629	0.1861

*Significant at 5% level

Table 3. Multiple regression equation contribution of different characters towards grain yield of chickpea

Model Multiple	Regression equation	Major contribution on yield		
		Character	Percentage	R2
I	$Y=26.66+0.852x_1^{**}+0.607x_4+0.673x5^{**}-11.27x_6-0.121x_7$	Harvest index (x_5)	68.27	0.8841
		Dry matter accumulation (x_1)	27.29	
		100 seed weight (x_4)	9.22	
		light interception (x_7)	-3.22	
		K content seed (x_6)	-1.57	
II	$Y=26.00+0.989x_1^{**}-8.90x_2+0.63x_4^{**}+0.686x_5^{**}-11.23x_6^{*}-0.138x_7$	Harvest index (x_5)	68.82	0.8660
		Dry matter accumulation (x_1)	31.34	
		100 seed weight (x_4)	9.46	
		crop growth (x_2)	-4.45	
		light interception	-3.64	
		K content of seed (x_6)	-1.54	
III	$Y=24.82+0.936x_1^{**}-9.084x_x+0.011x_3+0.618x_4^{**}+0.650x_5^{**}-11.278x_6^{*}-0.129x_7$	Harvest index (x_5)	65.08	0.8962
		Dry matter accumulation (x_1)	29.58	
		100 Seed weight (x_4)	9.26	
		Total number of flower (x_1)	5.53	
		light interception (x_7)	-1.54	
		K content of seed (x_6)	-3.38	
		crop growth rate (x_2)	-4.53	

tion (90 DAS), GGR (60-989 DAS), total number of flower, 100-seed weight, harvest index. K-content of seed and light interception (80 DAS) included in the regression model shared 89.62% yield of chickpea (Table 3). It is the indication of cumulative impact of these parameters on yield. Almost these variables were also significantly correlated among themselves. When we consider only five variables viz., dry matter accumulation (90 DAS), 100-seed weight, harvest index, K-content of seed and light interception (80 DAS) in model I, then 88.41% yield of chickpea can be predicted (Table 3). 100-seed weight and have index included in model I were significantly correlated among themselves. It means that if we increase in single factor, reflection of increase will also be seen in another factor. In order to enhance productivity harvest index, dry matter accumulations and 100-seed weight should be increased intensively. Gupta and Ramkrishana (1997) also noted that 100-seed weight and harvest index has high amount positive effect on chickpea yield.

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RESPONSE OF SORGHUM TO IRON AND ZINC

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Due to exploitative agriculture soils are becoming deficient in micro-nutrients. Considering this objectives a field trial was organized in RBD comprising 9 treatments (Table 1) at Rajasthan College of Agriculture, Uadipur. The soil being loamy in texture and alkaline in reaction (pH-7.2) registered 0.026% available N, 24.9 kg P_2O_5/ha and 187 kg K_2O/ha.The zinc and iron status of the experimental site was 0.515 and 1.430 ppm, respectively. Recommeded dose of fertilizers (RDF) for the sorghum was 80 kg N+40 kg P_2O_5/ha applied through DAP and Urea. Half of nitrogen, entire quantity of phosphorus and 25 kg $ZnSO_4$ $FeSO_4$ were applied at sowing. Faliar spray of $FeSO_4$ at 0.15% and $ZnSO_4$ at 0.15% and $ZnSO_4$ at 0.2% was done twice at 15 and 30 days after sowing along with half of the quantity of lime to balance the pH. Atrazine was applied as pre-emergence at 0.5 kg/ha to arrest the growth of weeds. The test variety was CSH-9.

It is explicit from the data reported in Table 1 that micro-nutrient application recorded early bloom than absolute control. Height of the plant parameter for fodder yields was also significantly improved. Further micro-nutrient application obtained bolder seeds a compare upto control.

Table 1. Influence of micro-nutrient application on yield and yield attributes of sorghum

S No.	Treatments	50% bloom	Plant height (cm)	1000-grain weight (g)	Grain yield (q/ha)	Fodder yield (q/ha)
1.	Soil Fe + RF	52.0	189.3	23.2	34.16	67.20
2.	Soil Zn+RDF	51.3	188.7	22.9	34.10	68.88
3.	Foliar-Fe+RDF	51.3	190.3	23.4	36.06	70.12
4.	Foliar-Zn+RDF	52.3	190.0	22.8	35.89	71.28
5.	Soil Fe+Zn+RDF	51.0	191.7	23.3	34.27	68.18
6.	Foliar-Fe-Zn+RDF	51.7	191.0	23.7	34.60	66.97
7.	RDF	53.0	192.0	24.1	30.80	71.28
8.	50% RDF+FYM (ton/ha)	55.7	191.0	22.3	19.32	59.92
9.	Absolute control	63.3	162.7	20.1	11.92	38.80
C.D. at 5%		1.4	3.9	1.3	5.54	2.90

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Application of soil-Fe, soil-Zn, foliar Fe, foliar Zn, soil Fe+Zn and foliar Fe+Zn significnatly augmented the grain yield amounting to percent increae of the order of 186.5, 186.0, 202.5, 201.0, 187.5 and 190.2 respectively over absolute control. 50% RDF+FYM (Source of micro-nutrient) was also superior over control. Application of Fe and Zn individually/in combination via soil and plant registered significantly higher fodder yield over that of control. The higher grain yield registered under micro-nutrient application could be attributed to early bloom and bold seeds i.e. higher-1000-grain weight. Higher fodder yield was due to the more plant height under these treatment. These results are in close conformity with the findings at Parbhani, Indore and Palem (Anon, 1994-95).

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EFFECT OF DIFFERENT SPACINGS ON GROWTH AND YIELD OF CABBAGE

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A field experiment was conducted at Horticulture Farm of S.K.N College of Agriculture, Jobner during winter *(rabi)* season of 1997-98, which is situated at 26.5^0 north latitude and 75.28^0 east longitude on elevation of 427 meters above mean sea level at Jaipur district of Rajasthan. Average rainfall is 500 mm, most of which has been received during July to mid September. Water of this area is saline in nature, falls in class C_4S_4. The pH of water was found to be 7.7, EC 3.05 mmhos/cm at 25^0C and sodium content was 25.0 meg/litre. The soil type was sandy loam with pH 8.5, EC 0.29 mmhos/cm at 25^0C, soluble cations 9.00 meg/litre, potassium 0.42 and calcium + magnesium were 5.00 and soluble anions (meg/litre) were carbonate (0.50), bicarbonate (3.50) and chloride (8.50). The experiment was laid out in a randomized block design with four replications and three levels of spacing, S_1 (30 × 45 cm), S_2 (45 × 45 cm) and S_3 (60 × 45 cm) were maintained. Four nursery beds of 2 × 1 meter size were prepared and 10g seeds per bed were sown in rows.

The seedlings were ready for transplanting in six weeks at 4.5 cm height. The row to row distance was kept 45 cm and plant to plant was 30, 45 and 60 cm according to three levels of spacing. The number of plants according to three levels of spacing was S_1 (72 plants), S_2 (48 plants) and S_3 (36 plants) on plot size of 9.72 m^2. All other cultural practices like irrigation, fertilization, inter-culture operations, plant protection measures etc. were done timely as per recommendation to grow a normal crop. Ten plants were randomly selected in each plot and tagged for recording observations. Among winter vegetables, cabbage (*Brassica oleracea* var. *capitata Linn.*) is important crop grown throughout India and highly valued for its medium size compact head and higher yield. The improved cultivation practices and modern farming methods are being adopted for its intensive cultivation. Since the cabbage crop is raised through seedlings, therefore on appropriate planting distance is most important factor to secure maximum income per unit area. However, very little information is available on the effect of different spacing on growth and yield on cabbage crop, so the present investigation was carried out.

The data presented in Table 1 revealed that the plant height was not affected significantly with the increasing levels of spacing at all stages of crop growth. However, the farthest spacing S_3 (60 × 45 cm) resulted in maximum plant height. Number of leaves per plant significantly increased with increasing levels of spacing at 30 and 60 DAT. The per cent increase in number of leaves per plant were 8.33 in treatment S_3 over S_1 at 30 DAT. At 60 DAT, the per cent increase in number of leaves was 9.98 in treatment S_3 recording maximum number of leaves (13.99) over S_1. Stem diameter (cm) was significantly increased with the increasing levels of spacing viz., S_1, S_2, and S_3. The highest diameter of 1.28 cm was recorded with the spacing of S_3 (60 × 45 cm) whereas at S_2 (45 × 45 cm) and S_1 (30 × 45cm) spacing was recorded 1.15 and 1.00 cm, respectively (Table 1). Maximum leaf area (315.41 cm^2) was recorded at S_3 (60 × 45cm) while minimum (310.83cm^2) at the spacing of S_1 (30 × 45cm) at harvest. The preqeut investigation shaved that increasing levels of spacing significantly increased the number of leaves per plant at 30 and 60 DAT and stem diameter at harvest may be due to more area available for the plants at widest spacing receiving more sunlight and lesser competition for nutrients due to less number of plants accommodated at widest spacing (S_3). The present results are in agreement with Strandberg (1985), Singh and Neopaney (1993).

The data pertaining (Table 1) shows that the S_3 spacing (60 × 45cm) significantly increased the head weight (g) over the treatment S_1 (30 × 45 cm) while S_3 and S_2, S_2 and S_1 were statistically at par to each other. The maximum average head weight (831.25g) recorded under the spacing S_3, while the minimum (766.33g) was observed at the spacing S_1. The per cent increase in head weight was 8.47 per cent under S_3 over S_1. There was significant increase in biological and economical yield with closest spacing S_1 over the widest spacing S_3.

Table 1. Effect of different spacings on growth parameters yield and harvest index in cabbage.

Spacings	Plant height(cm)			No. of leaves per plant			Stem diameter(cm)		Leaf Area(cm²)		Head weight (g)	Biological yield (q/ha)	Economic yield (q/ha)	Harvest Index (%)
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	45 DAT	At harvest	45 DAT	At harvest				
S_1(30×45 cm)	9.10	13.43	18.41	6.48	12.72	16.88	0.605	1.000	277.16	310.81	766.33	399.08	282.91	71.25
S_2(45×45 cm)	9.23	13.44	18.79	7.01	13.48	17.16	0.616	1.141	282.58	310.84	790.83	389.22	271.77	70.76
S_3(60×45 cm)	9.27	14.70	19.66	7.02	13.99	17.88	0.630	1.280	284.16	315.41	831.25	374.01	263.19	70.0
S.Em±	0.126	0.490	0.510	0.091	0.108	0.36	0.013	0.026	2.96	3.28	77.91	5.94	4.13	0.52
C.D. 5%	NS	NS	NS	0.265	0.314	NS	NS	0.077	NS	NS	52.13	17.20	12.03	NS

NS = Non-significant DAT = Days after transplanting

However, significant differences could not be recorded between S_3 and S_2, S_2 and S_1. Maximum per cent harvest index (71.25) was obtained under S1 while minimum was at S_3 (70.29). The increasing levels of spacing significantly increased the average head weight, whereas closer spacing resulted in higher biological and economic yield. Prabhakar and Srinivas (1987) reported that head yield significantly increased with increasing plant density as well as the maximum yield was obtained at closest spacing. Similar findings were also reported by Mullins and Straw (1990) in broccoli, Patil *et al.* (1995) in cauliflower.

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EFFECT OF FOLIAR APPLICATION OF UREA, SURFACTANTS AND ETHYL OLEATE ON NUTRIENT CONTENT OF PEACH GRAFTS

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Nitrogen applied to the tree basin is not adequately available to the plants due to leaching or otherwise, which does not meet the requirements of the tree and thereby trees suffer from disorders related to N deficiency. Under such conditions, foliar application of N provides the best alternative. Among the N fertilizers, urea is eminently suited for foliar feeding and gives quick response. Foliar urea is readily absorbed by leaves, which has been provided to be an efficient mean for improving fruit set, size and yield of temperate fruit plants (Shim *et al.* 1972) but stone fruits (peach, plum, apricot) in general are less responsive to foliar feeding of urea as compared to apple (Joon and Bhutani, 1990). The lack of desired response of stone fruits to foliar absorption of urea is reported to occur due to low wettability of the leaf surface besides covering of guard cells, which are important sites of foliar entry (Franke, 1964). However, the use of surfactants alongwith urea may greatly improve wetting of the leaf by way of lowering the surface tension and consequently reducing the contact angle between the liquid and leaf surface (Leece, 1976), which may faciliates the absorption of foliar urea. Besides surfactants, the chemicals, which can help to break the continuity of waxes on leaf surface of dissolve the waxes can also increase the absorption of urea. Unfortunately, such studies are lacking in peach. Hence, the present studies were undertaken with the objective to study the effect of foliar application of urea, surfactants and other chemicals on nutrient content of peach plants, which would later determine the flowering or fruiting behaviour of the plants in the following season. Studies were carried out at the experimental orchard of Department of Pomology, Dr. Y.S. Parmar University of Horticulture and Forestry, Solar (H.P.) during 1999 and 2000. The plants of July Elberta peach were first raised on one-year-old wild peach seedling rootstock. One plant per plot was planted and maintained at uniform cultural conditions in a glass house. Thereafter, different chemical treatments were given to the plants to verify the proposed hypothesis of the study following completely randomized design. Each treatment was replicated thrice. Nine treatment combinations viz., control (water spray) = T_1; T_2 = urea (0.5%); T_3 = urea (0.5%) + Tween 80 (0.1%)(S_1); T_4=urea(0.5%) +Triton X-100(0.05%)(S_2); T_5=

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urea(0.5%)+Stickwell (0.1%)(S_3); T_6 = Ethyl oleate (2%) in 3% potassium carbonate followed by urea (0.5%) + S_1 after 5 hour; after five hour; T7 = Ethyl oleate (2%) in 3% potassium carborate followed by urea (0.5%); T_8 Ethyl oleate (2%) in 3% potassium carbonate followed by urea (0.5%) +S_2 after 5 hour; T_9 = Ethyl oleate (2%) in 3% potassium carbonate followed by urea (0.5%) + S_3 after 5 hour. The plant nutrient leaf content were estimated in the leaves at 2 stages, (i) 72 hour after the spray and (ii) during August, which is the recommended leaf sampling time for peach. Leaf samples were collected and processed as per the procedure of Chapman (1963). Total nitrogen and phosphorus were determined by micro-Keldahl's method (A.O.A.C., 1980) and determination of K, Ca and Mg were carried out on Pye UNICAM SP-1900 spectrophotometer. The data generated from different studies were pooled and subjected to analysis using CRD statistical design (Cochran and Cox, 1963).

Foliar application of urea alone or in combination with ethyl oleate could not significantly influence leaf N levels of peach leaves either after 72 h of spray or during August. However, slight increase was observed when urea (0.5%) was applied in combination with different surfactants and ethyl oleate. During August, the leaf N content was below the optimum range in all the treatments (Table 1). Highest per cent increase in leaf N content was below the optimum range in all the treatments (Table 1). Highest per cent increase in leaf N over control was observed when urea (0.5%) plus tween - 80 (0.1%) was applied 5 h after 2% ethyl oleate application followed by the application of urea (0.5%) plus Triton X-100 (0.05%) in conjunction with (2%) ethyl oleate. Phosphorus content in leaves was not significantly affected by any of the treatments either after 72 h of spray or during August but a slight decrease in leaf P concentration was observed when urea was applied in combination with different surfactants and ethyl oleate. Further, the leaf P concentration was in the optimum range in all the treatments during August (Table 1). Like P, no significant difference in leaf K content was observed with any treatment. However, urea in combination with surfactants and ethyl oleate exhibited a slight decline in leaf K content. The leaf K content was above the optimum range in all the treatments (Table 1). No treatment could manifest any significant influence on leaf Ca levels either after 72 h of spray or during August. However, foliar urea sprays in combination with different surfactants and ethyl oleate tended to increase the leaf Ca levels. The highest increase was observed with T_9 treatment (Table 1). All the treatments failed to show any significant influence on leaf Mg concentration at both the intervals of observation. However, slight increase was observed with T_9 or T_8 treatments after 72 h of spray or during August sampling. The leaf Mg concentration was in the optimum range in all the treatments when except urea (0.5%) either alone or in combination with Triton X-100 (0.05%) or tween-80 (0.1%) or Stick well (0.1%), 5 h after ethyl oleate (2%) were applied (Table 1).

Foliar application of urea alone or in combination with surfactants and ethyl oleate proved to be ineffective in influencing

Table 1. Effect of foliar application of urea, surfactants and ethyl oleate on leaf nutrient status of peach plants (per cent dry wt.)

	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium	
Treatment	72 h after spray	At leaf sampling time	72 h after spray	At leaf sampling time	72 h after spray	At leaf sampling time	72 h after spray	At leaf sampling time	72 h after spray	At lea samplin time
T_1	1.91	1.79	0.24	0.24	2.76	2.65	0.95	0.90	0.55	0.50
T_2	1.95	1.82	0.24	0.23	2.73	2.62	0.98	0.91	0.58	0.52
T_3	2.00	1.87	0.23	0.22	2.65	2.53	1.04	0.98	0.64	0.56
T_4	2.08	1.89	0.23	0.22	2.62	2.56	1.06	0.99	0.65	0.55
T_5	1.98	1.83	0.23	0.22	2.69	2.62	1.02	0.96	0.62	0.53
T_6	2.11	1.95	0.23	0.22	2.60	2.52	1.04	0.97	0.68	0.64
T_7	2.17	2.09	0.22	0.21	2.48	2.40	1.12	1.06	0.72	0.68
T_8	2.16	2.08	0.22	0.21	2.46	2.42	1.14	1.07	0.75	0.66
T_9	2.14	2.02	0.22	0.21	2.54	2.48	1.10	1.01	0.70	0.64
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

the foliar nitrogen content of peach plants analysed. However, a slight increase in leaf nitrogen content ranging from 2.7 to 16.5 per cent over control was observed with the application of different foliar urea treatments. Poor response of peach plants to the foliar sprays of urea may be attributed to higher wax deposition, poor leaf wetting and resistance to water penetration as peach waxes are reported to be rich in hydrocarbon and triterpenoids (Leece, 1976) and due to covering of guard cells with waxes (Franke, 1964). Similar insignificant effects of different urea treatments in combination with surfactants and ethyl oleate on leaf has also been reported by Weinberger (1949), though, contrary to these findings, Norton and Childer (1954) have reported that peach leaves can absorb and utilize some of the nitrogen applied to foliage as urea, but it is not as efficient as apple in this aspect.

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YIELD AND ECONOMICS OF RICE AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

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Though India is ranked first in area and second in production at the global level, its productivity is less than 2 t ha^{-1} which is far below than many rice producing countries. Nutrient management must be sound for achieving the production targets on sustainable basis. Although use of chemical fertilizer is the fastest way of counteracting the pace of nutrient depletions. The ever rising energy cost and input availability coupled with many other factors affect farmers from using these inputs balanced proportions and in recommended quantities. From technical, economical, logistical and environmental considerations, the best course is to practice integrated nutrient management. This will harmoniously integrate the use of mineral fertilizers and organic manures to the extent possible without any detrimental effect on potential yield. The use of organic manures such as green manuring and application of FYM and poultry manure have been proved to be viable components of integrated nutrient management for rice across the globe.

A study was undertaken to assess the yield and economics of rice as influence by conjunctive use of organic and inorganic nutrient sources, on sandy clay loam soils of Rajendranagar Campus of Acharya N.G. Ranga Agricultural University during kharif 2000. The experiments site is situated at an altitude of 542.6m above mean sea level on 78°20'E longitude and 17°9' longitude. This soil had pH 8.1, EC-0.38 dSm^{-1}, organic carbon 0.56. Available nitrogen, available phosphorus and available potassium 193.31 and 162 kg ha^{-1} respectively. BPT-520H (Samba mahsuri) was chosen as test variety.

There were fourteen treatments comprising of three levels of fertilizers (75, 100 and 125% RDF) alone and in conjunction with three organic sources (10 t FYM, 5t poultry and 10 t glyricidia ha^{-1}) along with control and fertilizers based on soil test crop response. The experiment was laid out in randomized block design and replicated thrice grain yield (kg ha^{-1}) straw yield (kg/ ha^{-1}), cost of cultivation (Rs ha^{-1}) gross return (Rs ha^{-1}) net returns (Rs ha^{-1}) and benefit cost ratio were observed. T_1-Control (NoPoKo), T_2 - Fertilizer dose based on soil test crop response (STCR), T3 -75% Recommended Dose of Fertilizers (RDF), T4 - 100% RDF, T5-125% RDF, T6 - 75% RDF + 10t Farm Yard Maure (FM) ha^{-1}, T_7-100& RDF + 10t FYM ha-1, T_8 - 125% RDF+ 10t FYM ha^{-1}, T_9 - 75% RDF + 5t Poulrty Manure (PM) ha^{-1}, T_{10}- 100% RDF + 5t PM ha^{-1}, T11-125% RDF + 5t PM ha^{-1}, T_{12} - 75% RDF + 10t glyricidia ha^{-1}, T_{13}- 100% RDF + 10t glyrcidia ha^{-1}, T_{14} - 125% RDF + 10t glyricidia ha^{-1}.

Grain and straw yield obtained among 100% and 125% and RDF along with 5t PM ha^{-1} and 10t glyricidia ha^{-1} (T_{10}, T_{11}, T_{13} and T_{14}) was on para and the four treatments gave significantly higher grain yield compared to rest of the treatments . At a given level of RDF, grain yield obtained wit organic sources of poultry and glyricidia was comparable both the sources gave significantly higher grain yield compared to FYM the favourable effect of conjunctive use of poultry manure and glyricidia with inorganic fertilizers on grain yield wad due to elevated stature of growth parameters and more yield attributes. Straw yield behaved similarly as that of grain yield. These results are in agreement with the findings of Dubey and Verma (1995), Raju and Reddy (1997) and Budhar *et al.* (1991). The results are in agreement with the findings of Gupta *et al.* 1995 and Raju and Reddy, 1997. Dubey and Verma (1995) and Budhar *et al.*, (1991).

Gross and net returns contained with 100% and 12% RDF alonwith 5 t poultry manture ha^{-1} and 10t glyricidia ha^{-1} were on par and all the four treatments were significantly superior to rest of the treatments. Maximum benefit cost ratio of 1.24 was obtained with 100% RDF + 10t glyricidia ha^{-1} but it was on par with 100% and 125% alone and in conjunction with 5 t poultry manure ha^{-1} and 125% RDF + 10t glyricidia ha^{-1}. The results are in accordance with the findings of Madhavi (1992) (Table 1).

Table 1. Effect of integrated nutrinet management on yield and economics of rice

Treatmetns	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit cost ratio
T_1-Control	30.72	40.64	10748	17392	6644	0.62
T^2-Fertilizer based on STCR	4689	5717	13312	26303	12991	0.98
T_3 - 75% RDF	4348	5322	12728	24401	11673	0.91
T_4-100% RDF	5091	6107	13480	28508	15028	1.11
T_5 - 125% RDF	5137	6173	14078	28771	14693	1.04
T_6-75% RDF + 10t FYM ha^{-1}	4531	5552	15228	25431	10203	0.67
T_7 - 100% RDF + 10t FYM ha^{-1}	5361	6443	15880	30126	14246	0.90
T_8-12% RDF + 5t FYM ha^{-1}	5452	6465	16478	30488	14010	0.85
T_9 - 75% RDF + 5t PM ha^{-1}	4957	5985	14498	27777	13279	0.91
T_{10}-100% RDF + 5t PM ha^{-1}	5890	6909	15130	32904	17774	1.17
T_{11}-125%RDF+5t PM ha^{-1}	5899	6922	15728	32965	17628	1.10
T_{12}-75% RDF+10t glyricidia ha^{-1}	4962	5965	13973	27792	13819	0.99
T_{13}-100% RDF+10t glyricidia ha^{-1}	5873	6901	14655	32815	18160	1.24
T_{14}-125% RDF + 10t glyricidia ha^{-1}	5882	6919	15253	32869	17716	1.15
SEm±	31	49	-	481	415	0.09
C.D. (P=0.05)	89	143	-	1395	1206	0.26

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INFLUENCE OF IRRIGATION SCHEDULING ON YIELD, CONSUMPTIVE USE OF WATER, WATER-USE EFFICIENCY AND ECONOMICS OF RABI SUNFLOWER (*HELIANTHUS ANNUUS*)

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Sunflower has been proved to be a highly promising crop under different agroclimatic regions of India because of thermo-insensitivity and high production potential. Its oil is considered to be of high quality due to high quality of high percentage of poly-unsaturated fatty acids (60%). It is a recently introduced crop in India and especially in Rajasthan and become increasingly popular among the farmers, therefore, little information is available on various aspects of its successful cultivation. The success of its cultivation mainly depends on proper irrigation schedule, but the information on the aspects is very meager, therefore, the present experiment was undertaken to determine proper irrigation schedule.

Field experiment was conducted for 3 years in rabi seasons of 1995 to 1998 at Agricultural Research Station, Kota. The soil of the experimental plot was clay loam which had medium available nitrogen and potassium and low available phosphorus with pH 7.8. The field capacity and permanent wilting point were 28.0 and 15.2%, respectively. Ten irrigation schedules, based on critical growth stages (CGS) and IW : CPE ratio (irrigation at bud formation (BF, I_1), disc formation (DF, I_2), seed development (SD, I_3), BF + DF (I_4), DF + SD (I_5), BF + SD (I_6), BF + DF + SD (I_7) and at IW : CPE ratio 0.4 (I_8), 0.6 (I_9) and 0.8 (I_{10}) were tried in randomized block design with four replications. One common irrigation was applied before sowing at 100 mm depth and the remaining irrigations were scheduled as per treatment at 60 mm depth. The sunflower variety MSFH-8 was sown at a row spacing of 60 cm and fertilized with recommended dose of NPK.

The results (Table 1) revealed that three irrigations at critical growth stages (CGSs) recorded significantly highest seed yield (26.04 q ha^{-1}) over other treatments; however, it was at par to I_{10} (25.0 q ha^{-1}) with five irrigations based on IW : CPE ratio of 0.8. The yield (20.18) q ha^{-1}) obtained with one irrigation at DF (I_2) was significantly high over one irrigation at BF (I_1) or at SD (I_3) and was at par to BF + DF (I_4), I_8 (IW : CPE = 0.04) and I_9 (IW : CPE = 0.06) with 2, 3 and 4 irrigations, respectively. This shows that disc formation was the most CGS. Similarly, highest seed yield could be obtained with less number of irrigations at CGSs as compared to IW : CPE ratio because water applied at CGSs is

Table 1. Effect of irrigation scheduling on seed yield, consumptive use of water (CUW), water use efficiency (WUE), net returns and B:C ratio of sunflower (Mean of three years)

Treatment	No. of irrigation	Amount of water used (mm)	Seed yield (q/ha)	CUW (mm)	WUE (kg/ha-mm)	Net return (Rs./ha)	Benefit : cost ratio
I_1, BF	1	160	16.90	156.8	10.97	10.490	1.63
I_1, DF	1	160	20.18	140.9	14.30	13.770	2.14
I_1, SD	1	160	18.75	138.0	13.58	12.340	1.92
I_1, BF+DF	2	220	21.49	172.9	12.42	14.770	2.19
I_1, DF+SD	2	220	22.18	180.2	12.29	15.460	2.30
I_1, BF+SD	2	220	22.53	191.5	11.74	15.810	2.35
I_1, BF+DF+SD	3	280	26.04	241.4	10.77	19.010	2.70
I_1, IW:CPE=0.4	3	280	18.77	210.0	8.92	11.740	1.67
I_1, IW:CPE=0.6	4	340	21.51	242.9	8.85	14.170	1.93
I_1, IW:CPE=0.8	5	400	25.00	320.4	7.80	17.350	2.25
C.D. (P=0.05)			1.72				

most efficiently utilized by the crop for growth and development. The consumptive use of water was higher from irrigations based on IW : CPE ratios compared to irrigation at CGSs, were as water use efficiency (WUE) decreased with increasing IW : CPE ratio being higher by irrigating at CGCs, where WUE was highest with one irrigation at disc formation (I_2) indicating the WUE decreased with increasing frequency of irrigation because of more losses of water. The results confirms the findings of Khade *et al.* (1994) and Singh *et al.* (1997). The net return and B:C ratio was highest by irrigating the crop at BF+DF+SD.

It may be concluded that with three irrigations at CGSs (BF+DF+SD) under unlimited and one irrigation at disc formation, under limited water availability, the production of sunflower can be sustained and by large WUE may also be promoted.

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EFFECT OF SULPHUR AND PLANT GROWTH-REGULATORS ON YIELD AND QUALITY PARAMETERS OF CHICKPEA (*CICER ARIETINUM* L.)

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Being a cheapest source of proteins, pulses are often refereed as poor man's meat in developing countries. Pulses from an integral part of farming system and the vegetarian diet in Indian sub-continent. Besides being a rich source of protein, they maintain soil fertility through biological nitrogen fixation and thus play a vital role in furthering sustainable agriculture. Chickpea is one the major *rabi* pulse crop which has high digestible dietary protein (17-21 percent). Chickpea is also rich in calcium, iron, niacin, vitamin C and vitamin B. Its leaves contain maleic acid which is very useful for stomach ailments and blood purification. Sulphur is best known for its role in the synthesis of sulphur containing amino-acids like methionine and cysteine. Sulphur deficiency and its responses in case of pulses is quite remarkable (Lal and Jaiswal, 1981). Use of plant growth-regulators (PGRs) have been reported to induce physiological efficiency including photosynthetic ability of the plants which mitigate the adverse effects of aberrant weather conditions to some extent and result in better growth and yield of several agronomic crops without any substantial increase in cost of production (Jain *et al.* 1988). Keeping this in mind, a field experiment was carried out to study the effect of sulphur and plant growth-regulators on yield and quality of chickpea.

An experiment was conducted during the *rabi* season of 1998-99 at S.K.N. college of Agriculture, Jobner (Rajasthan). The climate of this place is typically semi-arid characterized by aridity of the atmosphere and extremity of temperature both in summer and winter. The soil was loamy sand with pH 8.4, organic carbon 0.19 percent and available sulphur 8.4 ppm. The treatment consisted of four levels of sulphur (0, 20, 40 and 60 kg ha^{-1}) and four PGRs including control (water spray, NAA at the rate of 20 ppm, cycocel at the rate of 50 ppm and MH at the rate of 50 ppm), thus making 16 treatment combinations. The experiment was laid out in fractional randomized block design with four replications. Sulphur was applied as basal dose through gypsum and PGRs applied as foliar sprays twice at bud initiation and pod formation stages. A uniform dose of 20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} were applied in each plot.

Sulphur application significantly improved the grain yield, straw yield, protein contents in grain, and sulphur content ins straw and grain(Table 1). The per cent increase in grain yield over control due to 20, 40 and 60 kg S ha^{-1} was 17.99, 32.69

and 46.52 per cent, respectively. The increase in parameters might be due to the role of sulphur in synthesis of sulphur containing amino-acids, carbohydrate metabolism, protein synthesis, energy transformation and chlorophyll synthesis. Beneficial effect might be also due to better availability of N, P, K and S and their translocation. The results confirmed the findings of Lal and Srivastava (1985) and Tripathi *et al.* (1997).

Application of PGRs showed significant increase in yield (straw and grain) and quality of chickpea. The increase in grain yield due to NAA, cycocel and MH was 25.42, 24.16 and 26.12 per cent, respectively, over control (water spray). The protein content of grain increased over control due to NAA, cycocel and MH in order of 19.98, 17.91 and 20.65 per cent, respectively. The increase in grain yield and protein content in grain were statistically higher due to MH in compare to other treatments. NAA enhanced the early flowering and fruit setting, number of flower buds, flowers and pods per plant and also promotes early flowering and pod setting. Cycocel and MH application help the plants to make resistance to drought and could, which is main cause of flower drop and poor pod setting. These also caused delay in senescence hence increased net period for seed development. The same findings were reported by Singh *et al.* (1991).

Table 1. Effect of S and PGRs on yield and qulaity of chickpea

Treatments	Yield (q/ha)			S content (%)	
	Straw	Grain	Protein content in grain (%)	Straw	Grain
S kg ha^{-1}					
0	19.12	13.67	19.31	0.159	0.356
20	22.06	16.13	20.61	0.196	0.382
30	24.28	18.14	21.44	0.231	0.418
40	26.96	20.03	22.37	0.256	0.436
C.D. at 5%	1.00	1.42	0.82	0.012	0.013
PGRs					
Water spray	19.85	14.24	18.26	0.193	0.376
NAA	24.14	17.86	21.91	0.216	0.401
Cycocel	23.96	17.68	21.53	0.215	0.402
MH	24.46	18.10	22.03	0.217	0.403
C.D. at 5%	1.00	1.42	0.82	0..012	0.013

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RELATIVE PROFITABILITY OF POTATO VARIETIES IN INDORE DISTRICT OF MADHYA PRADESH

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Potato is an established profitable vegetable crop in the country. It had a record yield of 24 million tonnes from 1.2 million hectares in 1997-98, emanating approximately 19.6 tones of production per hectare, which however has potential to increase immensely for improving cost-benefit ratio. In Indore, Jabalpur, Rewa, Sagar and Gwalior district of M.P., there is a vast cultivation of potato with production of 35525 tonnes (Rajput *et al.* 1996).

Like wheat and rice, green revolution in potato has also taken place since mid-sixties which was ushered in due to indigenous development of improved potato varieties, development package of practices for all the important potato growing regions of the country and transfer of potato production technologies (Kumar and Sharma, 1999)

Kufri Giriraj is a medium maturing, late blight resistant potato variety, which yields higher than Kufri Jyoti at 110-12- days. It has been recommended for general cultivation as a main season variety in the hilly regions of Himachal Pradesh, Uttar Pradesh, Meghalaya and Tamil Nadu (Joseph and Singh, 1999).

The present study is concerned mainly with the relative profitability of different potato varieties (Kufri Lavkar, Kufri Jyoti and Kufri Sindhuri). Two stage random sampling technique was adopted to select the villages and cultivators for the present study. Four villages were selected randomly from Indore tehsil of Indore district. Further twenty-five potato growing farmers were selected randomly from each village. Their categories were classified according to their holdings as small farmers (0 to 2 ha), medium farmers (2.1 to 4.0 ha) and large farmers group size (above 4 ha). Forty farms were selected from small and 36 from medium and 24 from large size group. This study is related to 100 farmers of four villages of Indore tehsil of Indore district during the year of 1999-2000.

An overall view of results presented in Table 1 revealed that overall returns (Rs. 26754) and net return (Rs. 6788) were highest of Kufri Jyoti in comparison of other two varieties Kufri Sindhuri and Kufri Lavkar. Among three varieties, lowest gross return (Rs. 23781) and net returns (Rs. 6165) were observed of Kufri Lavkar.

The share of Kufri Jyoti was 74

Table 1. Average gross and net return (Rs./ha) and input output ratio for different varieties of potato (1999-2000)

Size group	Variety	Yield/ha	Cost of production (Rs./q)	Cost of cultivation	Gross return	Net return	% deviation from weighted average	Input-output ratio
Small	K. Jyoti	32	151.56	19400	26384	6984	105.06	1:1.36
	K. Sindhuri	9	133.82	18200	25480	7280	103.57	1:1.40
	K.Lavkar	7	152.67	17100	22914	5814	100.58	1:1.34
	Weighted average	48	100.15	18500	24235	5735		1:1.31
Medium	K. Jyoti	30	156.69	19900	25870	5970	103.12	1:1.30
	K. Sindhuri	12	139.25	18800	24816	6016	109.34	1:1.32
	K. Lavkar	9	162.84	17750	22365	4615	98.36	1:1.26
	Weighted average	51	152.42	20180	26032	5852		1:1.29
Large	K. Jyoti	27	158.46	20600	26265	5665	107.05	1:1.27
	K. sindhuri	8	134.55	18300	23973	5673	110.64	1:1.31
	K. Lavkar	5	155.93	18100	23350	5250	102.54	1:1.29
	Weighted average	40	160.00	22280	28295	6015		1:1.27
Overall	K. Jyoti	86	155.61	19966	26754	6788	104.10	1:1.34
	K. Sindhuri	29	132.60	18433	25990	7557	107.50	1:1.41
	K. Lavkar	21	155.90	17616	23781	6165	100.51	1:1.33
	Weighted average	136	158.41	21640	27699	6059		1:1.28

percent of the total cropped area. Group wise the area of Kufri Jyoti was observed to be 71.6 percent on small, 66.6 per cent on medium and 76.5 percent on large farms. The variety covered major part of the potato cropped area, because it require less input as compared with Kufri Sindhuri and gave better yield per unit area. The profitability of this variety was higher on large farms.

The cost of cultivation of variety Kufri Jyoti was highest (Rs. 19966) in all size groups when compared among the three varieties. The cost of production per quintal was estimated to be lowest Rs. 140/q in Kufri Sindhuri and Rs. 160/q for Kufri Lavkar among the three size groups. Overall the cost of production of potato was lowest (Rs. 140/q) on small farms and highest (Rs. 160/q) on large farms.

The overall gross returns per hectare was found to be highest (Rs. 19966) for variety Kufri Jyoti followed by (Rs. 17616) for Kufri Lavkar. Overall net returns per hectare was highest for Kufri Sindhuri.

Among the three varieties (Kufri Jyoti, Kufri Lavkar and Kufri Sindhuri) of potato, Kufri Sindhuri was found to be most profitable when compared with the other two varieties (Kufri Jyoti and Kufri Lavkar). The overall profitability for Kufri Sindhuri, Kufri Jyoti and Kufri Lavkar was estimated, 1:1.40, 1:136 and 1:1.34, respectively. Kufri Sindhuri was also found to be with highest productivity on all categories of farms followed by varieties Kufri Jyoti and Kufri Lavkar.

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OCCURRENCE OF SESAME POD BUG (*ELASMOLOMUS SORDIDUS FABRICIUS)* ON SESAME IN VELLORE AND *THIRVANNAMALAI* DISTRICTS OF TAMIL NADU

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Sesame, *Sesamum indicum* Linn. (Pedaliacea) is one of the important oil seeds in India. It is cultivated mostly under rain fed condition in dry areas of marginal and sub marginal farm holdings and also under irrigated condition, where the water source is available. Among the insect pests attacking the sesame, the lygaeid bug Elasmolomus sordidus Fab. was reported to cause extensive damage to the crop in India (Distant, 1903). It has been also reported from many countries viz. West Aftica, Sudan, Gulf of Oman, Nigeria, Portuguese Guinea, Brazil, Gambia, Bangladesh, Ceylon, Burma and China (Corby, 1947). In India, it was reported to occur in Assam, Nagaland, Bengal, Calcutta, Maharashtra (Distant, 1903), Madhya Pradesh. (Sharma, et al., 1990), Bihar, Gujarat, Andra Pradesh and Karnataka (Shasikant Udikeri and Deshpande, 1996). In Tamil Nadu, it was reported from Coimbatore on groundnut (Ramachandra Rao, 1928) and from Vridhachalam on-sesame. (Mohanasundram et al., 1980). Though this bug was considered as a minor pest on groundnut, of late, it has assumed a major economic importance due to the extensive damage caused to sesame, This lygaeid bug is commonly known as "Ekkadayan or Yelkudayan" in Tamil, since it sucks the oil from the seeds of sesame and caused reduction in seed weight and oil content (Mohanasundaram and Sundara Babu, 1987).

A survey was conducted in seven taluks of Vellore and six taluks of Thiruvannamalai district for the incidence of sesame pod bug during 1996. In each taluk, two blocks were selected for the survey. A total of ten plants were selected at random on the sesame field and the number of bugs present on ten plants were counted in each block. The blocks surveyed for the incidence of pod bug are indicated Fig. 1.

Survey conducted at Velloore and Thiruvannamalai districts revealed that pod bug was prevalent in all the taluks of both the districts. In Vellore district, the bug population per plant ranged from 8.5 in Natrampalli block to 20.5 in Vellore block. The men population per plant in different taluks were 7.1 (Thirupathur), 10.6 (Vaniampadi), 14.5 (Gudiyatham), 17.9 (Vellore), 14.0 (Arcot), 13.6 (Walajah) and 16.1 (Arakonam). The district average was 13.4 bugs/lant (Table 1). In Thiruvannamalai district, the mean bug population/plant ranged from 9.4 (Anakkavur) to 24.7

Table 1. Occurrence of sesame pod bug, *Elasmolomus sordidus* in Vellore and Thiruvannamalai Districts

S.No.	Name of the taluk	Name of the block	Mean Bug Population/plant	
			Block	Taluk
I	**Vellore district**			
1.	Thirupathur	Natrampalli	8.5	
		Kandili	5.7	7.1
2.	Vaniampadi	Vaniampadi	10.3	
		Madanur	10.9	10.6
3.	Gudiyatham	Gudiyatham	10.7	
		K.V. Kuppam	18.4	14.5
4.	Vellore	Vellore	20.5	
		Anaicut	15.3	17.9
5.	Arcot	Arcot	12.5	
		Timiri	15.5	14.0
6.	Walajah	Walajah	11.4	
		Kaveripakkam	15.8	13.6
7.	Arakonam	Panapakkam	18.7	
		Nemeli	13.5	16.1
			Mean (District	13.4
II.	**Thiruvannamalai district**			
8.	Cheyyar	Cheyyar	10.4	
		Anakkavir	9.4	9.8
9.	Vandavasi	Vandavasi	15.3	
		Peranamallur	12.4	13.9
10.	Arni	Chetpet	10.9	
		Kannamangalam	17.5	14.2
11.	Polur	Polur	10.2	
		Kalasapakkam	12.4	11.3
12.	Thiruvannamalai	Thiruvannamalai	15.3	
		Keelpennathur	18.5	16.9
13.	Chengam	Chengam	21.5	
		Thandarampattu	24.7	23.1
			Mean(District)	14.86

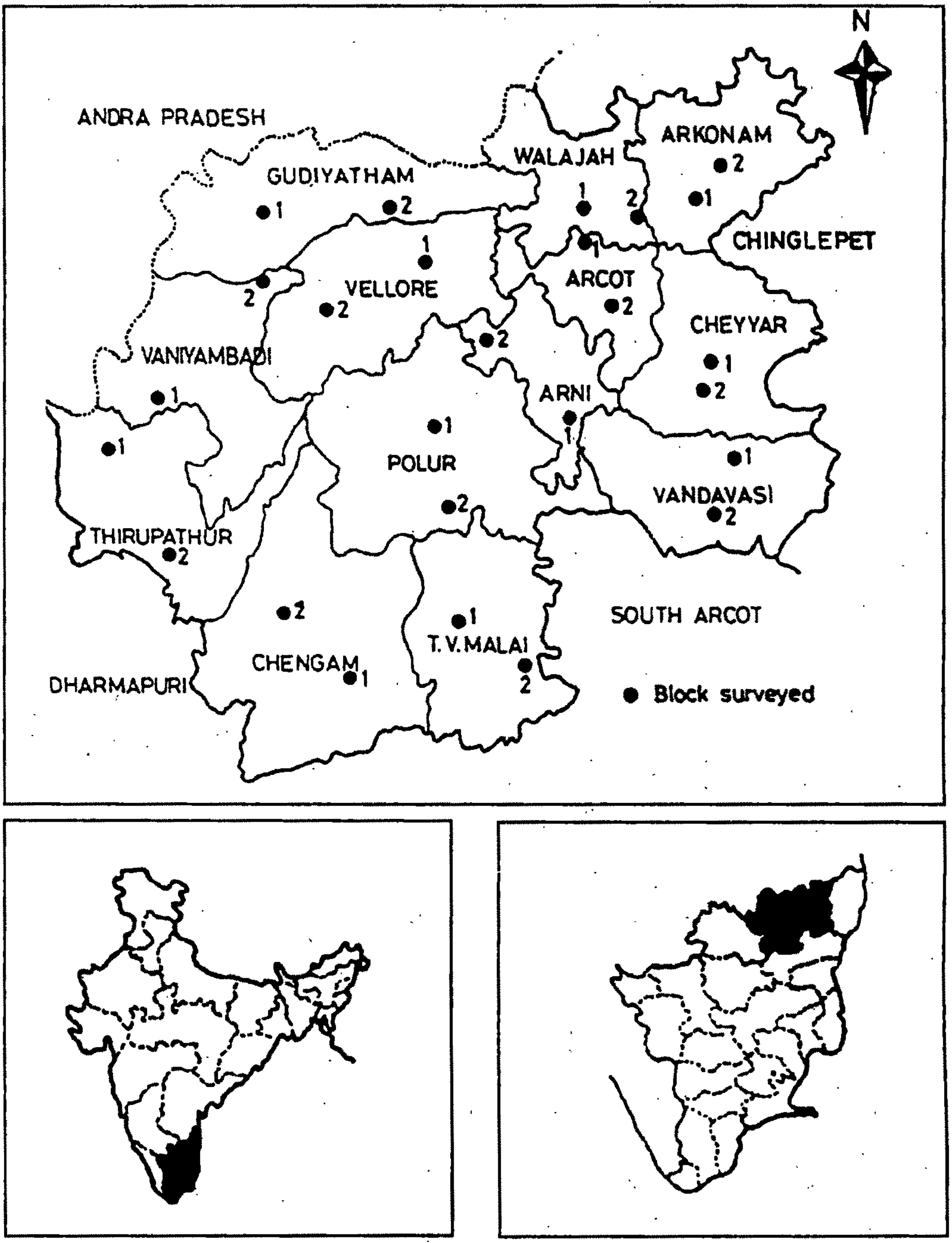

Fig. 1 : Occurrence of sesame pod bug in Vellore and Thiruvannamalai District

(Thandarampattu) at the block level. The taluk wise mean population recorded were 9.8 (Cheyyar), 11.3 Polur), 13.9 (Vandavasi), 14.2 (Arni), 16.9 (Thiruvannamalai) and (Chengam). The district average was 14.86 bugs/plant.

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POPULATION, BIOMASS AND NUTRIENT UPTAKE OF WEEDS IN SUNFLOWER AS INFLUENCED BY WEED MANAGEMENT

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Inspite of recent introduction, the sunflower became increasingly popular among Indian farmers, due to high yield potential an quality of oil produced coupled with desired traits like photo thermo insensitiveness, higher seed multiplication ratio and early maturity.

National average productivity of sunflower is only 590 kg ha^{-1} which is less than half of world's average. Weed is one of most important biotic stress responsible for low productivity, as sunflower plants are slow growing in initial stages, and sown in wider rows, which provide enough space and other resources for weed. This cause reduction in seed yield of sunflower to the extent of 42 to 67 per cent. Therefore, it became necessary to develop an efficient weed management schedule to ensure a weed free environment to sunflower crop to obtain maximum yield and higher input use efficiency. Keeping in view the paucity of information pertaining to these issues, the present field experiment was undertaken.

A field experiment was conducted during *kharif* 1999 at IARI, New Delhi. The soil was sandy loam and low in organic carbon (0.28%), medium in available P (10.25 kg/ha) and available K (235.05 kg/ha) with pH 7.8. The treatments comprised four measures of weed control viz., weedy check, two hand weeding (20 and 40 DAS), pendimethalin @ 1 kg a.i./ha and pendimethalin @ 1 kg a.i./ha + 1 hand weeding and five levels of nutrients in sub plots. Thus 20 treatment combinations were tested in split plot design with three replications. The sunflower Hybrid MSFH-8 was sown on July29th, one irrigation was given at 55 DAS. Weed flora in experiment plot consisted of a mixed population of grass and broad leaf weeds, the important grass weeds were *Panicum repens L., Eragrostis tenella* L., *Digitaria sanguinalis* L. Scop., *Dactyloectenium aegypticum* L. and *Cynodon dactylon L.* Pens; and broad leaf weeds were *Trianthema portulacastrum* L., *Digera arvensis* Frost, *Commelina benghalensis* L., *Portulaca oleracea* L., *Phyllanthus niruri*, among sedges only *Cyperus rotundus* L. was present.

Weed control measures brought about marked reduction in both monocot and dicot weeds. Maximum reduction in weeds was recorded under pendimethalin @ 1 kg/ha + 1 HW, and proved significantly superior to rest of treatments except pendimethalin @ 1 kg a.i./ha alone (Table 1). Pre-emergence application of pendimethalin resulted in controlling the early germinating weeds and one hand weeding given at 30 DAS was found good enough to take care of late emerging weeds (Girijesh and Patil, 1992).

Table 1. Effect of weed management measures on weeds/m^2, dry matter/m^2, nutrient (N&S) contnet (%) and nutrient uptake (kg/ha) of weeds in sunflower and yield of sunflower

Treatments	Weed population* (No./m^2)				DM* (g/m^2)			Nutrient content (%)		Nutrient uptake (kg/ha)		Seed yield (q/ha)	Stover yield (q/ha)
	30 DAS		60 DAS		30 DAS	60 DAS	Harvesting	N	S	N	S		
	Monocot	Dicot	Monocot	Dicot									
Weedy check	12.7	17.2	13.0	18.5	13.1	16.6	15.3	2.25	0.12	52.4	3.0	11.0	33.7
Two hand weedings (20 and 40 DAS)	10.9	15.4	11.1	17.3	11.6	14.9	13.7	2.27	0.12	42.6	2.4	12.2	35.0
Pendimethalin @ 1 kg a.i./ha	10.2	12.4	10.8	15.5	10.5	13.0	12.2	2.26	0.13	33.9	1.9	12.4	36.7
Pendimethalin @ 1 kg a.i./ha+ 1 HW (30 DAS)	10.1	11.6	10.4	15.1	10.0	11.9	11.5	2.29	0.13	30.6	1.7	13.2	37.1
SEm±	0.24	0.27	0.16	0.30	0.20	0.25	0.19	0.03	0.004	0.91	0.04	0.25	0.86
C.D. 5%	0.83	0.95	0.58	1.04	0.61	0.89	0.69	NS	NS	3.1	0.14	0.80	2.1

* Value of population and dry matter is transformed (square root) and not original.

Minimum dry matter accumulation by weeds was also noticed in pendimethalin @ 1 kg a.i./ha+HW treatment which might be due to reduction in weed population with application of pendimethalin @ 1 kg/ha + 1 HW.

There was no significant effect of weed control measures on nitrogen and sulphur content of weeds. However, significant reduction in N and S uptake by weeds was recorded under all weed control measures over weedy check. Pendimethalin @ 1 kg a.i./ha 1 + HW was found to be the most efficient treatment in respect of reducing the N and S removal by weeds. This was due to weeds suppressing ability of this particular treatment. In fact, nutrient uptake by weeds is function of dry matter production and nutrient content of weeds (Malipatil and Patil, 1990).

All weed control measures brought about a significant improvement in seed and stover yield as compared to weedy check. Pendimethalin + 1 HW produced highest seed and stover yield, might be due to cumulative effect of reduced crop weed competition as evident by lower weed density, dry matter accumulation and low N and S uptake by weeds. These results corroborates the findings of Legha *et al.* (1992).

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INHERITANCE OF DWARF PROFUSE TILLERING HABIT IN RICE (*ORYZA SATIVA* L.)

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Materials used in the study were single dwarf profuse tillering mutant, CH 45 and three tall shy tillering lines namely Neela, Ratna and CR 749-33.

CH 45 was crossed with Neela, Ratna and CR 749-33 during rainy season at Central Rice Research Institute, Cuttack. F_1, F_2 and F_3 generations were evaluated in randomized block design replicated thrice with 20 cm × 15 cm spacing between row and plant, respectively. Recommended cultural practices were followed for trials. Plant population for F_2 and F_3 generations were 300 and 45, respectively. Single seedling was transplanted in all F_1, F_2 and F_3 generations. Observations were recorded for number of Ear Bearing Tiller/Plant(EBT) and plant height (cm) at maturity.

The data were subjected to x^2 analysis to test the mode of inheritance of the trait.

Number of EBT of CH 45 grassy mutant parent was alarmingly higher than other three parents, i.e. Neela, Ratna and CR 749-33. However, plant height of CS 45 grassy mutant is quite sorter in comparison to other parents.

Dominance of tall shy tillering habit plant type over dwarf profuse tillering habit was observed in F_1 generation for all three crosses (Table 1). The F_2 generation showed segregation in the ratio of 13 tall shy tillering and 3 dwarf profuse tillering in all the crosses indicating the action of two dominant inhibitory genes for the trait. It was also found that all three tall, shy tillering cultivars viz. Neela, Ratna and CR 749=33 are having same genetic makeup. Proposed genotype for these three tall varieties is TTss, whereas, the genotype for dwarf profuse tillering cultivar is ttss.

Segregation of pooled F_3 progeny (Table 2) also confirmed the observed F_2 ratio of 13 tall shy tillering and 3 dwarf profuse tillering. Sugimoto (1923) reported that the dwarf mutant showed dominance and F_2 gave a 3:1 ratio of dwarf to normal forms. However, parnel et al., 1922; Akemino, 1925; Nagai, 1926; Jones, 1933; Ramiah, 1933 b; Kadam, 1937 a; Morinaga et al., 1942; observed that dwarf forms behaved as recessives in F_2, monogenic segregation was common but in several crosses, more than one locus was involved confirming ratio of 9 : 3 : 3 : 1, 15 : 1 & 13 : 3.

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Table 1. Inheritance of profuse tillering CS 45 grassy dwarf mutant of rice in F_1 & F_2 generations

Crosses	F_1	No. of F_2 plants T	 D	Total	x^2	P values
Neela × CH 45 (Tall) (Dwarf)	Grassy Tall	482	109	591	0.035	0.90-0.00
Ratna × CH 45 (Tall) (Dwarf)	Grassy Tall	469	115	584	0.339	0.70-0.50
CR 749-33 × CH45 (Tall) (Dwarf)	Grassy Tall	459	120	579	1.482	0.30-0.20
Pooled		1410	344	1754	0.855	0.50-0.30
Heterogeneity					1.001	0.70-0.50

Table 2. Segregation of profuse tillering Ch 45 grassy dwarf mutant of rice in F_3 progenies

Phenytypic classes in F_2	Total progenies studied	No. of F3 progenies showing segregation ratio of All Tall	 (13T:3D)	 (3T:1D)	 (1T : 3D)	 All dwarf	x^2	P values
Tall	161	39 (3)	47 (4)	75 (6)	–	–	0.104	0.90
Dwarf	50	–	–	–	31 (1)	19 (1)	0.491	0.50–0.30

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PRODUCTIVITY POTENTIAL OF PIGEONPEA (*CAJANUS CAJAN* L. MILLSP) GENOTYPES IN RESPONSE TO GROWTH REGULATORS UNDER *VERTISOLS* OF CHHATTISGARH PLAINS

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Pigenpea occupies a distinct position among kharif pulses in Chhattisgarh. It occupies an area of 27 lakh ha with a production of 11.8 m t and productivity of 445 kg ha^{-1}. Low productivity of pigeonpea can be ascribed to the constraints associated with its indeterminate growth pattern causing excess vegetative growth which ultimately result in shading of lower plant parts and low photosynthesis. Its productivity is further limited due to short phase of high crop growth rate, profuse flowering, low pod set, leaf senescence in post reproductive phase and low dry mater accumulation in seed (Saxena, 1984). There is need for scientific manipulation by choosing suitable plant ideotype and regulating plant growth through growth regulating chemical, which can check the excessive vegetative growth, thereby creating proper balance between source and sink for enhanced crop yield. Keeping the above facts in view, the present investigation was carried out to assess the influence of growth regulators on the productivity of pigeonpea genotypes in Vertisols of Chhattisgarh plains.

The field experiment was carried out during kharif season of 2000-01 at the Instructional Farm, Indira Gandhi Agricultural University, Raipur (CG). The soil of experimental field was clayey in texture (Vertisols), neutral in reaction (pH 7.19) with low nitrogen (218 kg ha^{-1}), medium phosphorus (12.15 kg ha^{-1}), and high potassium content (365.33 kg ha^{-1}). The treatment consisted of two genotypes (Asha and C-11) and two growth regulators 2, 4-D @ 20ppm and Cycocel @ 1000ppm) and one control. The experiment was laid out in RBD (factorial) design with 3 replications. The crop was sown on 5th August with a seed rate of 20 kg ha^{-1} and spacing of 60 × 10 cm. Recommended dose of fertilizer was applied @ 20 kg N, 50 Kg P_2O_5 and 30 kg K_2O ha^{-1} uniformly as basal. One irrigation was given by sprinkler just after sowing for proper germination of seeds. The plant population was maintained by thining manually at 20 days after germination. Two hand weedings were done at 20 and 45 DAS. At harvest, seed yield, stalk yield and yield attributing characters (pods $plant^{-1}$, seed pod^{-1}, pod weight $plant^{-1}$ and 100 seed weight) were recorded. Pod setting index productivity rating index, production efficiency, heat use efficiency and growing degree days were computed by their respective formula. Chlorophyll content of leaves at 120 DAS was estimated by acetone extraction procedure (Yoshida et al., 1972).

The result revealed that the yield attributing characters viz. number of pods Plant^{-1}, number of seeds pod^{-1}, 100 seed weight as well as seed and stalk yield were found to be statistically higher in genotype Asha as compared to C-11. the high yield in former genotype might be correlated with its better performance in relation to yield attributing characters. The result in with close conformity of findings of Jarillo et al. (1998), Patel et al. (1988), Bhute et al., (1998) and Saraf and Hegde (1984). The productivity rating index was found to be non-significantly more efficient cv Asha that cv C-11 reflecting its suitability for the region. A similar trend was observed under heat use efficiency and efficient utilization of heat (Table 2). Balakrishnana and Natrajaratham (1986) observed that heat unit efficiency was significantly correlated with seed yield. The content of chlorophyll 'a' and 'b' and their 'total' was the highest in cv. Asha (Table 2).

The highest seed and stalk yield was obtained in cycocel and 2, 4-D respectively. Katole and Salim (1990) were of the opinion that cycocel being an antigibberelin compound reduced the plant height but increased yield due to activation and regulation of physiological processes within the plant. Arora et al. (1998) also observed similar results. The pods plant^{-1} was the highest with cycocel, whereas, seed pod^{-1} and 100 seed weight went in favour of 2, 4-D. Arora et al., (1998) were also of the views that pods plant^{-1} increased due to cycocel treatment. Heavier seed in case of 2, 4-D might be due to increased the mobilization of pod wall reserve for grain filling.

The highest value of productivity rating index and production efficiency were obtained in case of cycocel obviously due to the highest yield (Table 2). The heat use efficiency in terms of biological yield as well as seed yield indicated highest efficiency under cycocel and 2, 4-D from seed yield and biological yield considerations, respectively (Table 2). The treatments which accumulated more growing degree days showed lower efficiency for heat use in terms of dry matter accumulation as well as seed yield. It is only due to the inter relationship existing between them. Similar findings were also noticed by Rao et al., (1999). The leaf chlorophyll content determined at 120 DAS. More content of chlorophyll 'a' and 'b' and total chlorophyll were estimated from 2, 4-D treated plants (Table 2). Higher chlorophyll content due to 2, 4-D application was also reported by Panwer and Elanchezhian (1998).

Table 1. Yield attributes and yield of pigeonpea as influenced by genotype and growth regulators

Treatment	Pods Plant-1 (No.)	Seeds Pod^{-1} (No.)	Pod weight plant^{-1} (g)	100-seed weight (g)	Pod setting index (%)	Seed yield (qha^{-1})	Stalk yield (q ha^{-1})
Genotypes							
Asha	199.52	3.94	58.22	10.13	35.53	21.12	93.25
C-11	182.90	3.63	54.87	9.83	39.64	16.80	81.87
SEm±	3.85	0.05	2.80	0.08	1.21	0.55	0.99
C.D. at 5%	11.61	0.15	NS	0.28	3.64	1.66	2.99
Growth Regulators							
Control	157.06	3.73	47.62	9.93	31.17	17.28	87.99
2,4-D @ 20 ppm	198.65	3.92	60.35	10.16	39.52	18.58	91.36
Cycocel @ 1000 ppm	218.35	3.70	60.92	9.85	42.08	21.02	83.33
SEm ±	4.72	0.06	3.43	0.10	2.32	0.68	1.21
C.D. at 5%	6.62	0.18	10.34	0.301	6.99	2.04	3.66

Table 2. Productivity rating index, Production efficiency, heat use efficiency and chlorophyll content of pigeonpea as influenced by genotypes and growth regulators

Treatment	Productivity rating index (%)	Production efficiency (kg ha^{-1} day^{-1})	Heat use efficiency (Kg ha^{-1} day^{-1})		Growing degree days at maturity (^{O} day)	Chlorophyll content at 120 DAS		
			Biological yield	Seed yield		'a'	'b'	Total
Genotypes								
Asha	84.51	11.04	4.09	0.75	2799.86	0.809	0.477	1.143
C-11	84.42	9.51	3.54	0.59	2770.13	0.794	0.437	1.127
SEm±	2.59	0.50	0.04	0.02	6.04	0.012	0.010	0.018
C.D. at 5%	NS	1.50	0.13	0.06	18.21	0.036	0.030	0.054
Growth Regulators								
Control	76.74	8.51	3.82	0.62	2747.43	0.570	0.334	0.758
2,4-D @ 20 ppm	83.39	10.52	3.94	0.66	2785.28	0.971	0.543	1.396
Cycocel @ 1000ppm	93.26	11.79	3.69	0.74	2822.27	0.863	0.495	1.250
SEm±	3.17	0.72	0.05	2.02	7.40	0.014	0.011	0.021
C.D. at 5%	9.54	2.17	0.16	0.07	22.31	0.042	0.033	0.063

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Ann. agric. Res. New Series Vol. **24** (2) : 453-454 (2003)

GENETIC VARIABILITY AND ASSOCIATION BETWEEN PLANT HEIGHT AND BASE DIAMETER IN CAPSULARIS JUTE

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Jute (*Corchorus capsularis*) is self pollinated crop, however some time as much as 10% out crossing. It requires humid and warm climate for growth. The plant height and base diameter are two important traits for fibre yield. Thus, the knowledge on the magnitude of genetic variability, correlation coefficient, heritability & genetic advance for these two characters in jute is essential for a breeder to select a superior parent for crop improvement. With the above objective, an experiment a superior parent for crop improvement. With the above objective, an experiment involving 80 germplasm lines was conducted in a randomized block design with three replication at Crop Research Station, Bahraich (U.P.) During kharif 2000. Observations were recorded on five randomly selected plants of each genotype per replication for plant height and base diameter.

The analysis of variance was done from the mean data obtained for both the characters Estimates of genetic parameters were computed as suggested by Johnnsen et. al. (1995). Phenotypic and genotypic correlation coefficients for both the characters were also estimated as suggested by Robinson *et al.* (1951).

The analysis of variance revealed highly significant differences among genotypes for these two characters. The estimate of various genetic parameters are presented in Table 1.

The phenotypic coefficient of variation was in general, higher than the genotypic coefficient of variation, which indicated role of environment in the expression of these two traits.

In the present investigation, the base diameter had high estimates of heritability high GCV and high GA % over mean while plant height showed high heritability, low GCV and low GA % over mean, high estimates of heritability (h^2) and genetic advance (GA%) was observed for base diameter. This may be due to positive additive gene action. However, Plant height had high heritability coupled with low genetic advance indicating that this character was under influence of non additive gene action was also reported by Mukewar et al. (1997) in Kneaf (*Hibiscus sabdreffa* L.)

The genotypic correlation was slightly higher in magnitude than the phenotypic correlation indicating inherent association between height and base diameter in jute.

Table 1. Estimates of genetic parameter, phenotypic (p) and genotypic (G) correlations for two character in jute.

Character	PCV	GCV	GA (% Overmen)	Heritability	Genotypic correlation between plant height & base diameter	Phenotype correlation between plant height & base diameter
Plant height	5.38	5.14	10.11	9.13	0.42	0.39 * *
Base diameter	18.51	16.88	31.68	83.1		

Components of variation	Plant height	Base diameter
PCV	5.38	18.51
GCV	5.14	16.88
GCV/PCV ratio	0.9	0.9
Heritability (%)	91.3	83.1
GA (% over mean)	10.11	31.68

1.	Genotypic Correlation between plant height & base diameter.	0.42
2.	Phenotypic Correlation between plant height & base diameter	0.39

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INFLUENCE OF INTEGRATED WEED MANAGEMENT ON ENERGETICS OF SOYBEAN

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Soybean cultivation is most popular during *kharif* season in Chhattisgarh, but the average yield in the state is quite low (7.97 q ha^{-1}). In monsoon season, weed infestation is one of the major factor which limits energy utilization and ultimately productivity level of crop. At present, consumption of energy has been increasing for improving the productivity, but energy use efficiency is declining. The use of conventional methods of weed control is expensive, time consuming and difficult under uncongenial conditions. Hence, it is essential to integrate the effective and workable weed management practices for efficient energy utilization. Keeping in view these facts, the present investigation was under taken to study the influence of FYM and various weed management practices on energetics of soybean.

The field experiment was conducted during *kharif* 2001 at Instructional Farm, IGAU, Raipur on black soil (*Vertisols*) having a pH 6.9, available N 220.14 kg ha^{-1}, available P_2O_5 13.60 kg ha^{-1} and available K_2O 358.45 kg ha^{-1}. The factorial experiment was conducted in randomized block design, consisted of two factor namely organic nutrient with FYM (5t ha^{-1}) and without FYM and weed management practices (6) formed in twelve treatment combinations, replicated thrice. Soybean variety "JS-335" was sown at the seed rate of 70 kg ha^{-1} in rows 30 cm apart. The crop was grown under rainfed condition. The uniform dose of NPK @ 30:60:20 kg ha^{-1}, respectively applied as basal.

The energy use efficiency was calculated by using the formulae.

Energy use efficiency ($MJq^{-1} \times 10^3\ ha^{-1}$)

$$= \frac{\text{Total produce (q)}}{\text{Energy input } (MJ \times 10^3\ ha^{-1})}$$

The treatment alachlor @ 2 kg ha^{-1} fb hand weeding with FYM (8805.68 MJ ha^{-1}) and alachlor @ 2kg ha^{-1} fb chlorimuron @ 4 g ha^{-1} with FYM (8772.32 MJ ha^{-1}) consumed maximum energy which were markedly higher than others. The energy outputs were relatively higher under alachlor @ 2 kg ha^{-1} fb hand weeding with FYM followed by single hand weeding with FYM because of higher biological yields. The energy output-input ratio was the highest in single hand weeding without FYM (9.09) which indicated its superiority in energy use efficiency (6.82 MJ q-1 × 10^3 ha^{-1}) over rest of the treatments. It might be due to higher crop bio-mass and lower energy input. Jain *et al.* (1998) also reported

Table 1. Energetics of soybean as influenced by FYM and various weed management practices

Weed management practices	Seed yield ($q\ ha^{-1}$)	Energy input ($MJ\ ha^{-1}$)	Energy output ($MJ\ ha^{-1}$)	Energy output-input ratio	Energy use efficiency ($MJq^{-1} \times 10^3\ ha^{-1}$)
Alachlor @ 2kg ha^{-1}	11.25	7266.48	49575.00	6.82	5.18
Chlorimuron @ 4g ha^{-1}	10.88	6788.40	53981.10	7.95	6.08
Alachlor + chlorimuron @ 2 kg + 4g ha^{-1}	16.35	7272.32	64497.00	8.87	6.69
Hand weeding at 30 DAS	17.24	6821.76	62030.30	9.09	6.82
Alachlor @ 2 kg ha^{-1} + hand weeding at 30 DAS	16.22	7305.68	58105.90	7.95	5.97
Unweeded check	9.37	6782.56	46423.90	6.84	5.23
FYM + Alachlor @ 2 kg ha^{-1}	12.53	8766.48	60444.10	6.89	5.26
FYM + chlorimuron @ 4 g ha^{-1}	10.87	8288.40	57516.40	6.94	5.32
FYM + alachlor @ 2 kg ha^{-1} + chlorimuron @ 4 g ha^{-1}	13.15	8772.32	54593.00	6.22	4.71
FYM+hand weeding at 30 DAS	16.11	8321.76	65394.20	7.86	5.94
FYM + alachlor @ 2 kg ha^{-1} + hand weeding at 30 DAS	16.90	8805.68	70705.50	8.03	6.08
Unweeded check (with FYM)	6.60	8282.56	38202.00	4.61	3.54

similar results. The lowest energy output input ratio and utilization efficiency were noted in unweeded check with FYM. All weed control treatments increased the energy use efficiency over unweeded check. Similar findings were also reported by Sharma and Thakur (1989).

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